CHEMICAL & METALLURGICAL ENGINEERING

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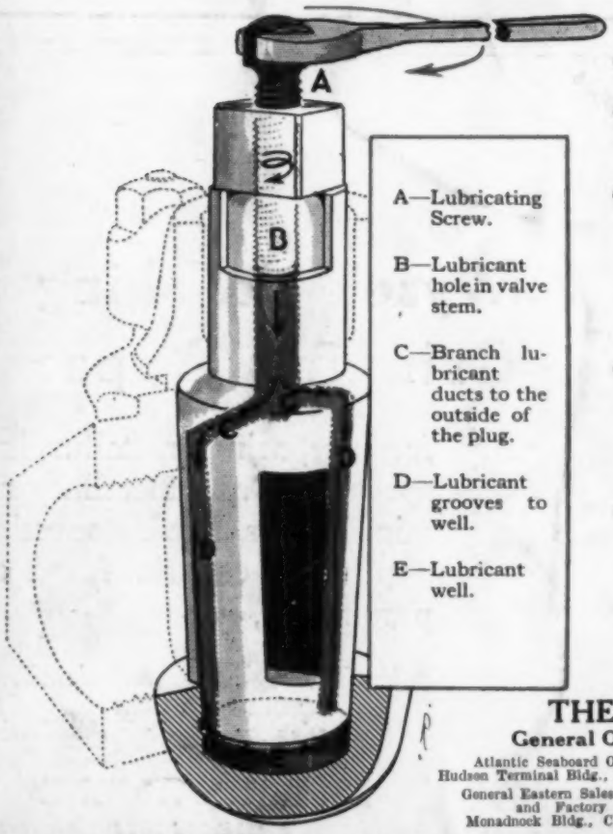

A—Lubricating Screw.

B—Lubricant hole in valve stem.

C—Branch lubricant ducts to the outside of the plug.

D—Lubricant grooves to well.

E—Lubricant well.

¶ It won't stick and it won't leak.

¶ Just a quarter-turn at the lubricating screw 'A.'

¶ And the lubricant is forced down through the hole in the valve stem, out to the surface of the valve plug, down the grooves 'D,' and into the well 'E.'

¶ Thus, the valve is not only lubricated, but the reaction upward at 'E' lifts the valve slightly, so that it WON'T STICK.

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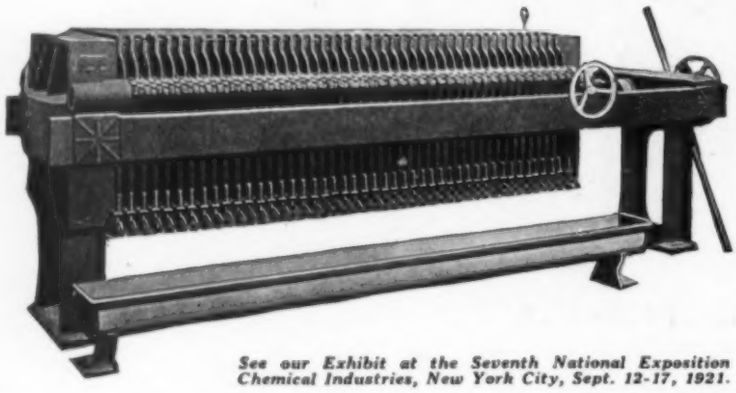

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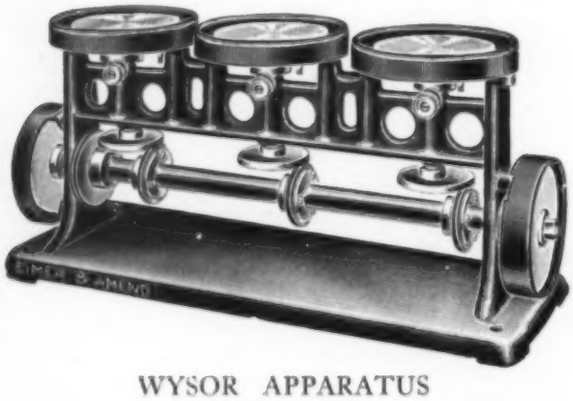

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The Chemical Exposition

THE Seventh National Exposition of Chemical Industries has gone into history, and when we consider the dullness of the times and the depression in all trade we can use the record to prove that chemical industry in the United States is alive. It is true that some of the exhibitors who usually make great displays reserved their space but showed no wares, merely equipping their booths as offices and reception rooms. Of these, however, there were but few, most exhibitors making their usual displays.

Although the trip to the armory at which the Exposition was held involved a long and weary journey—far beyond the Polo Grounds, which is "farthest north" for any but the most intrepid patrons of New York's rapid transit system—there was an attendance only slightly smaller than was recorded at Grand Central Palace last year. The immense floor of the armory provided ideal exhibition conditions and exhibitors seemed to be well satisfied not only with the number of spectators but with the volume and character of the inquiries. It was a quality crowd. Far fewer "literature hounds" overran the premises. By the same token, fewer inquiries came from entire strangers. Most of the callers were old friends and visitors looking for valuable improvements or innovations.

It will be good news, however, that by a large majority the exhibitors voted to hold the 1922 Exposition in the old quarters at Grand Central Palace. This more convenient location, nevertheless, has the disadvantage of its merit in that the crowd of visitors becomes almost unmanageable and the vast number of curiosity seekers makes it difficult for interested persons to get information. Something will have to be done to regulate the attendance and restrict it to an appropriate class.

It will be news to many, as it was to us, that the plan to remodel Grand Central Palace into an office building was never consummated. Accordingly the building is still available for expositions, although a year ago its owners officially declined to consider the Chemical Exposition for 1921 on account of the proposed change. This forced the Chemical Exposition management to look for new quarters, resulting in the selection of the armory.

On the whole the Exposition was a great success. Some criticism could be recorded, but most of it pertains to the matter of location, which will not be a bothersome factor next year. All things considered, there was little complaint, although we have not yet heard from those who deftly purloined from the exhibit of the U. S. Industrial Alcohol Co. bottles of clear water-white liquid labeled "Ethyl Alcohol" but containing *aqua pura*. Doubtless when those individuals fondly began to mix their cocktails they concluded that the Exposition was a snare and delusion.

The Shoemaker And His Last

ANNUALLY for several years past there has been some mild talk on the part of a few exhibitors at the Chemical Exposition in favor of organizing for the purpose of holding and controlling an exposition of their own. Apparently the thought was inspired by a feeling that the Exposition Company was growing rich at the expense of the exhibitors and that the latter might as well run their own exposition on a mutual basis, and benefit accordingly. Perhaps this type of reaction and line of reasoning are natural enough, but we doubt if the reasoning is sound and logical.

We hold no brief for the Exposition Company. In fact we know nothing of it except through contact with its two managers. But we think it is possible by giving a little thought to the subject to see the futility of such a proposal as has recurred with the close of each exposition. The conduct of expositions is a business, just as the manufacture of chemical equipment or the publication of a chemical magazine is a business. It requires money, brains and organization. Expositions do not spring into full-fledged existence over night, nor do they manage themselves. Somebody works the year round on the Chemical Exposition.

There is no reason to believe that an association of manufacturers conducting their own exposition on a mutual basis could achieve the results of the last seven expositions without resorting to the same means that have made those expositions increasingly successful. If a mutual organization of manufacturers were to attempt to conduct their own organization they would find it necessary, first, to provide the money through subscription to capital stock; second, to employ skilled and experienced exposition managers to conduct their business for them, and third, to devote considerable time to the conduct of the association's affairs. If there is anything attractive in this scheme it is not apparent on the surface. The net result would be additional burdens and inevitable disappointment and dissatisfaction due to attempting something entirely outside the training and experience of those who would undertake the task.

The whole conception is based on an industrial fallacy. Extended to its logical limit, it would involve each man doing everything for himself instead of allowing a specially qualified man to do one thing for a large number of us. That the promoters of the Chemical Exposition have made money is not to be doubted, otherwise they would not have continued in the business. Presumably the same is true of every exhibitor in his particular line of business. Business ventures succeed and make money because they render a service—real or imaginary. The Exposition Company has taken advantage of a great opportunity, but we believe it has also rendered a real service. If that service has not been all that it should be, there is no more cer-

tain way of improving it than by frank consultation and co-operation with the management or its advisory committee. No permanent good can be accomplished by holding aloof or indulging in carping criticism.

If we may judge from the way in which space has already been taken for next year's show, we may justly conclude that the proposal for exhibitors to hold their own exposition will make no substantial headway, and we hope it will not. Let the shoemaker stick to his last. If there is no satisfactory reason for the existence of the present Exposition, certainly none can be advanced for a substitute. We believe that the Chemical Exposition Company has a useful purpose to serve and that it has shown itself worthy of the support of the chemical industries. That the management has made mistakes there is no doubt, but it is equally certain it has been open to constructive criticism and has acquired experience that can only be increasingly useful as long as chemical expositions are held.

The Rubber Industry And the Planters

WHEN an American visualizes the word rubber he thinks of factories, tires, tubes, belts, hose, etc., for our end of the rubber industry is manufacturing. But in Europe, particularly in the British Isles and Holland, the reaction is entirely different. Your traveled Englishman will think of countless waving trees among which flits the inevitable coolie with his can of latex, for the British are the planters.

Taking the year 1919 rather than 1920 as a basis, a study of statistics shows that the United States consumed 68 per cent of the world's production of rubber, which amounted to 339,000 tons. The production for 1920 was 368,000 tons, practically 89 per cent of which was produced on the plantations of the Far East. Our British cousins own about 75 per cent of the plantation acreage, which in 1919 reached a total of 2,181,000 acres in bearing with 730,000 acres yet to come in. Their investment amounts to about $300,000,000, of which by far the larger portion is held by small investors throughout the British Isles.

America therefore stands as best customer to the plantation industry. About 70 per cent of the rubber consumed in this country goes into tires and tubes. Consequently anything that affects the tire industry is soon the cause of no little concern in Great Britain. Unfortunately for the planters, their business has been built on a steadily rising American demand. When that demand is curtailed or cut off, there is no other market in which to dispose of the surplus. The situation from the Britisher's point of view has been rather well summarized by H. P. STEVENS in a recent issue of the *Journal* of the Society of Chemical Industry.

The chief difficulty is that our friends the planters have developed practically a one-market business. The depression of 1920-21, which played such havoc with our one-product tire factories, naturally raised Ned with the price of plantation rubber, which dropped from 40-50c. per lb., the normal price range of 1918-19, to 10-15c. This is considerably below the cost of production, which has been variously estimated at 18 to 25c. per lb. These are facts. The question is what to do about it.

The planters, through their association, are curtailing production. Their plan is evidently to produce only enough rubber to meet the demand. This will help, but will not furnish a complete remedy. The American depression, coming as it did from real and not imagined causes, cannot be expected to have a short period of convalescence. The recovery will be slow and gradual, and has been estimated at from two to five years before normal conditions will be reached.

The remedy for our one-product tire factories is to diversify, play to more than one market. The advice applies to the planters as well. Tea, coffee and other tropical products should be made a regular business and not a side line. In fact there appears to be no reason why the planters cannot turn their attention to cultivating other trees and shrubs yielding valuable materials such as the alkaloids and even the tannins.

For several years past the Rubber Growers' Association has offered handsome prizes for new uses for rubber. To date we know of no awards having been made. There are plenty of new developments under way, but they are the outgrowth of a definite demand. Most of these schemes have still several years of research ahead of them. It is possible that new uses will be developed, but not soon enough to have a serious effect on the market for the next five years.

All credit is given the planters for the high quality of plantation rubbers, but it will be admitted by practically all American rubber technologists that there is still something lacking. Fine para (true up-river fine) is still the best rubber produced in point of (*a*) uniformity in period of vulcanization; (*b*) nerve; (*c*) elasticity and tack; (*d*) viscosity of cement, and (*e*) life. These properties could be elaborated to considerable extent. Suffice it to say that the ignorant *seringueiro* of the Amazon country, who prepares his hams by a method passed down to him from the ages, produces a rubber in many ways superior to the finest product of the scientifically controlled plantation.

Superior cleanliness, constancy of supply and reasonable constancy of product, coupled with price, have been in favor of the planter in his battle with the wild rubbers. Research has been practiced on the plantations, but many things of little importance have been magnified far beyond their deserts. Isn't it time that an effort be made to get at the fundamentals of rubber production and to produce a superior product?

The Psychology Of Business

SOME keen observers of business conditions and trends have lately been expressing the opinion that business has become ripe for a decided turn for the better. They base their opinion not so much upon the concrete underlying facts as upon their appraisal of how men's minds will act. The lapse of time since business got into the dumps is a prominent factor. In war time it is shown that it is not in the nature of the human mind for the owner to be scared continuously. It is a feeling which the normal individual cannot hold steadily. The average business man, according to the view of many observers, cannot remain indefinitely in a lethargic condition, or in a condition of waiting. When prices began to decline, some manufacturers decided to shut up shop, and some even declared that they would not reopen until they got their price. After a time the condition of a closed factory grew irksome to the owner and he became disposed to make some goods even if it was not certain he could make money.

It is supposed to be a distinctly feminine trait not to assign the real reason for an opinion or course of conduct. That may not be the case with business men,

yet an observer can see that business men do something not altogether dissimilar in making selection of different sets of facts from one time to another to find a reason or an excuse for a line of conduct. The facts selected may be hard, even statistical, the selection, however, being due to the mental state.

From the great mass of business facts available one can, as a matter of fact, make selections that will be decidedly encouraging or decidedly discouraging, and if the selection is dictated by the mental condition, psychology rules conduct, even though statistics are paraded as the basis. One may say that business is very bad, for there are 5,000,000 persons out of employment, but one may also say that business is not so very bad and there must be a considerable volume of buying power, since 35,000,000 or 40,000,000 people are in employment. One may say that money is tight and collections are poor, but it may also be observed that a great many payments must be made, since the Federal Reserve Board reports debits to individual accounts at banks running only 15 or 20 per cent below those of a year ago.

There really is little difficulty in selecting a collection of facts that will justify a line of conduct in business when psychological conditions have settled the question whether the individual desires support for a policy of "taking hold" again or of waiting still longer before doing anything.

Now it is an actual fact, which everyone has had opportunity for years past to observe, that when business improves the reasons for the improvement are cited, in facts that already existed, and then many exclaim, "Why didn't we think of that before?"

Already there is some improvement in many lines of trade, and we may now look forward with confidence to the reasons for the improvement being duly set forth, after the fact. A year ago practically everyone realized that business and prices would have to be cast in a new mold, a process that would take time. Now we are ready to wake up to the realization that a year has elapsed, a year of great readjustment.

The Oppau Explosion

OUT of the chaos of newspaper misinformation gradually comes what seems to be a rational interpretation of the disaster at Oppau, Germany, which resulted from an explosion at the Haber nitrogen fixation plant located there. We are finally informed through press dispatches that it was an "explosive" which caused the damage and that it was not a huge tank of nitrogen which by *its* "explosion" caused the disaster. Also the mysterious new gas which was being compressed but whose "properties were not known" is no longer the guilty party even in the most garbled guesses of the layman.

An explosion of such suddenness and violence as to do damage twenty, thirty or even forty miles away as reported could not conceivably have been essentially a gas explosion. In the first place, it is very doubtful whether sufficient quantities of combustible or explosive gas existed at the plant to account for even the damage within the city of Oppau itself. And the characteristics of the explosion, if properly described in the press, are not those which result from the rupture of high-pressure containers. It seems evident, therefore, that it must have been some form of solid material which could be detonated that was the cause of the principal damage done. Of course in any such case the initial cause of trouble and to what extent the principal cause was a secondary explosion can be disclosed only by careful investigation, and perhaps not even then.

It is known that this plant has been for some time experimenting with mixtures of ammonium nitrate and sulphate for fertilizer use with the idea of developing a material of highest agricultural value that would also be free from the objection of deliquescence. Accumulations of this material or of ammonium nitrate may well have caused the major explosion and the extensive damage. Of course there are also possibilities of nitrated organic compounds of high explosibility that may have been under investigation as intermediates for dye manufacture. It is almost useless to speculate regarding these details, for even the best informed specialists in this country who have tried to keep in touch with the work at Oppau are unwilling to venture more definite opinion than that expressed above.

The Conference On Unemployment

SPECULATION is rife as to what may be accomplished by the President's conference on unemployment now in session in Washington. Granted that there is urgent reason for focusing the best thought of the country on the problem, what practical consequences can be expected? For the immediate relief of unemployment, which is the critical factor, it seems likely that little can be accomplished. But the conference will be worth the time and energy expended if it clearly formulates broad policies that will prove a remedy or at least a palliative for widespread unemployment in the future. The program of the conference has three phases: First, the presentation of recent reliable statistics of unemployment; second, the consideration of possible immediate remedies, and third, consideration of economic and industrial processes that will prove to be long-time remedies. As in the case of President WILSON'S First Industrial Conference, useful and practical results depend largely on guidance that will keep the conference from being sidetracked on non-essential issues such as controversies between employer and employee. Under Mr. HOOVER'S direction we may confidently expect the conference to avoid any such fiasco. The fundamental factors brought out will be recorded in the technical and business press of the country to the exclusion of more spectacular but less essential matters of controversy that may be featured by the newspapers.

Denying a Pernicious Rumor

UNFOUNDED rumor has been circulated during the last two weeks to the effect that cases of infantile paralysis exist in the vicinity of Lake Placid, New York, where the American Electrochemical Society will hold its regular fall meeting September 29 and 30 and October 1. We are glad to be able authoritatively and unqualifiedly to deny these rumors. Members of the Lake Placid Club who are also members of the American Electrochemical Society have the assurance of the club officials that there is no foundation for the rumor, and we have also made an investigation which satisfies us that conditions at the Lake Placid Club are normal and that there is no cause for alarm. Members of the Society and readers of CHEM. & MET. can confidently deny the rumor should it persist.

Readers' Views and Comments

The Slip Interference Theory

To the Editor of Chemical & Metallurgical Engineering

SIR:—I would like to congratulate the authors of the Slip Interference Theory on the excellent work they have done in examining the problem of hardening of metals, not only from the point of view of the usual hypo-eutectoid steel, but taking into consideration the other alloys as well. I especially appreciate the authors' reference to duralumin, one of the alloys of the future, and the marked tendency of the paper to find a general solution of the hardening problem.

Examination of the summary (clauses 1 to 8) as well as the text finds abundant proof as to the interest the authors have shown in the crystallography of alloys One may follow also with great interest the authors' argument that "every known method of hardening metals can be referred to the principle of slip interferences" and to the action of small "key-particles."

Further, the writer would like to emphasize that some of the facts derived from the study of damascene steel may be interpreted as supporting the authors' general views. So, for instance, the heat-treatment of damascene blades[1] could be more easily explained by taking into consideration not only the hardening phenomena as they are usually interpreted in hypo-eutectoid steels but the "keying" action of the small cementite particles as well. Hypo-eutectoid steel usually served as a point of departure for the theories of hardening of steel. In view of the absence of free cementite in these steels the influence of cementite particles was never sufficiently appreciated. Even the "carbon" theories sought for a new modification of carbon or of carbide and not for the possible rôle of the particles of the existing carbide in the hardened metal.

When studying damascene steel the writer came across the fact that such theories as would explain sufficiently well the hardening of hypo-eutectoid steel seemed unable to account for the heat-treatment of damascene blades or for their certain "high-speed hardness." He therefore sought for explanation elsewhere, and naturally enough was attracted by the idea that the presence of a large number of highly spheroidized cementite globules might furnish the necessary explanation. He must confess, however, that up to now he admits the hardening effect of cementite particles only to a certain degree and is rather reluctant to overestimate such influence. So, for instance, the properties of martensite seem to me to be best explained by its structure, which, "crystallographically" speaking, is characterized by Widmanstättian figures.[2] These figures result from the octahedral crystallization of steel and show that the elemental octahedra were deformed parallel to the four surfaces of the octahedron.

In austenite we have the gamma iron, and the iron carbide, cementite, is evenly dissolved in that iron. By rapid cooling it is possible to prevent the segregation of the carbide, and in martensite, where iron has passed from the non-magnetic gamma to the magnetic alpha state, cementite remains in a suspended form, as if in solution.[3] The sudden change of volume from gamma to alpha iron causes severe internal stresses which manifest themselves by deforming every elemental octahedron parallel to its four faces. The hardness of martensite results very likely from these internal deformations. I am therefore quite in agreement with the authors that martensite is alpha iron; where we differ is, first, that I consider martensite as a pseudo solution not of carbon, but of cementite in alpha iron; and further that not only the fineness of grain but chiefly the "Widmanstättian structure" of the deformed elemental octahedra is responsible for the hardness.

I do not think that colloidal suspended particles of cementite may act as keys in martensite. On the other hand, I join the authors in their appreciation of Captain Grard's curves. I am quite in agreement, therefore, with the authors' idea that the first "increase" in hardness after tempering is due to the "key" action of the segregating cementite.

The only reservation which the writer would like to make is that in this instance, as in other instances, the "key" action is responsible for a comparatively small increase in hardness and that there is a difference in scale between the "key" hardness and the "quenching" hardness.

While still believing that carbon in solid iron is present not as such but as iron carbide (or cementite),[4] nevertheless I do not think that if the authors were to consider austenite from that point of view it would in any way change the main deductions of their so brilliantly exposed theory.

COLONEL NICKOLAS T. BELAIEW.

London, England.

[1] Belaiew, "Crystallization and Structure of Steel," Thesis, Petrograd, 1909, p. 48. See also Belaiew, "Damascene Steel," *J. Iron and Steel Inst.*, 1918, p. 417.

[2] Thesis, p. 25.

[3] Thesis, p. 29.

[4] Thesis, p. 48-66.

Athletics and Chemistry

To the Editor of Chemical & Metallurgical Engineering

SIR:—I was very much interested to read in the last issue of your journal the short article on page 310 entitled "Athletics and Chemistry." In reading the article I immediately thought of the captain of the track team at the University of Illinois, John Prescott.

Mr. Prescott was graduated from the university in June, 1921, in the course in chemistry given here. You probably know the standing of the school of chemistry at the institution. He was a member of one of the largest and best-known college fraternities and was interested in a number of activities outside of his scholastic work. He was a member of "Pierrots," a campus opera organization, on the student council of the Illinois Union, elected to Ma-Wan-Da, the highest senior honorary society for activities, and the Tribe of Illini, an organization of athletes who have been awarded "I"s. In addition to these societies, he was elected to two honorary scholastic fraternities, Phi Lambda Upsilon, national honorary chemical fraternity, and Phi Beta Kappa for excellence in scholarship in the College of Liberal Arts and Sciences.

Prescott was a member of the varsity track team for three years, and was captain of the team his senior year. His best work was in the 220 low hurdles, but he does the "hundred" in "ten flat" and has done some distance work, being on the conference champion mile relay team in 1920. He captained the University of Illinois track team this past spring to the championship of the "Big Ten" conference, and then took his team to the national meet in Chicago on June 18, winning this meet and the championship of the United States.

He is a rare combination of quiet, likable personality, consistent athlete, par excellence student and chemist.

FRED H. TURNER,
Chief Clerk.

University of Illinois.

Italian Chemical Industries

FROM OUR SPECIAL CORRESPONDENT

GENOA, Italy, Sept. 6, 1921.

THE last five weeks has seen some activity in the Italian chemical and metallurgical market, although from the 7th to the 21st many operatives and employees were absent from the works on account of the summer holidays and the lire suffered a reduction in value, bringing down considerably the price in dollars or pounds of the chemicals manufactured. The lire prices of Italian and other chemicals did not, however, increase in all instances; some remained unchanged and others fell, in response to the volume of offers received from abroad, the heavier or lighter import duties, or the demand.

HYDRO-ELECTRIC DEVELOPMENTS

The construction of the hydro-electric plant that is destined to use the waters of the Lys is proceeding very satisfactorily, the principal difficulties having been overcome. The plants in the recently annexed Trento territory are fairly numerous. One of these is on the Sarco River and produces electric energy amounting to 15,000 hp., which is to be raised to 35,000 hp. in the next twelve months. Another, on the Ponale River, was destroyed during the war, but will soon be repaired and will produce 40,000 hp. There is a hydro-electric plant in the valley of the Flemme, on the River Avisio, which is used to work the mines of the Pedrazzo Works. Its 8,000 hp. will be brought later to 70,000, by the artificial creation of three new waterfalls. Besides these there is a hydro-electric plant of 40,000 hp. in the Venosta Valley (Etsch Werke) and several smaller ones.

ITALIAN FERTILIZERS

The Italian superphosphate industry, although supplying all national needs, is still greatly dependent on importations of the mineral phosphates, as can be gathered from the most recent statistics. During 1918 Italy imported 23,213 tons of such products, in 1919 44,932 tons and in 1920 40,000 tons. For the first four months of this year the importations reached 24,205 tons, against 12,605 tons for the corresponding months of 1920 and 14,050 in 1919. The largest quantities of mineral phosphates came from Tunis (22,077 tons) and from Egypt (517 tons). The demand for superphosphates is still low, owing to the fear of many that the prices will suddenly drop; for this reason very little was accomplished for the autumn and winter treatment of the ground. The same was the case with Italian cyanamide. This product, made either synthetically or from calcium cyanide, has been subjected to a higher importation duty, to encourage its local production. The importations of superphosphates increased during the first four months of 1921, reaching 322 tons out of a total of 5,405 tons of fertilizers imported. The importation of Thomas slag also increased considerably in that period, being 5,117 tons. In the case of ammonium salts the importations reached 202 tons in the first four months of the year, against 392 tons in 1920 and 3,271 tons in 1919 during the corresponding months.

ITALIAN SULPHUR

The crisis in the Italian sulphur industry became more acute during August, culminating in the strike of some of the miners, who refused to accept a decrease in wages in view of the fact that the price of food had increased considerably. A few days from the time this is written a conference will be held at the Ministry of Industry at Rome between the principal representatives of the industry and the representatives of the workpeople. After this meeting the Italian Government will study the situation and endeavor to find a remedy to offset the increased cost of production.

CARBONATE OF SODA

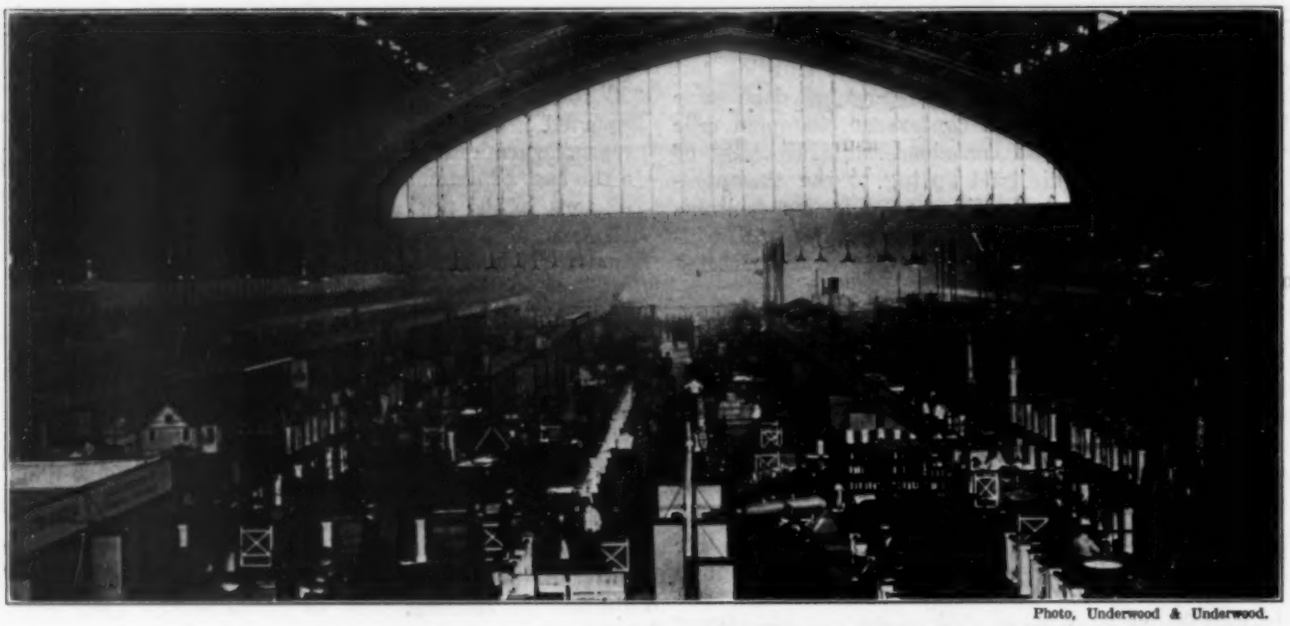
The manufacture and exportation of carbonate of soda received but little attention in the past, as can be gathered from the fact that Italy imported 34,252 tons in 1920, against 27,234 tons in 1919 and 22,651 tons in 1918, and exported only 66 tons in 1920, 26 tons in 1919 and 25 tons in 1918. The importations made in 1920 were distributed as follows: From the United States, 6,972 tons; from France, 15,967 tons; from England, 4,916 tons; from Spain, 3,278 tons; from Switzerland, 2,253 tons, and from other countries, 865 tons. This year, however, the case has been different, for during the first four months the importations were reduced to 1,836 tons, as against 10,447 tons in 1920 and 6,943 tons in 1919 during the corresponding period.

ITALIAN SOAP INDUSTRY

The Italian soap industry has been greatly developed since the war. In 1920 6,140 tons of common soap was exported to Albany, Austria, Czechoslovakia, England, Greece, Jugoslavia, Poland, Rumania, Switzerland, European Turkey, Asiatic Turkey, Egypt, Tripoli and other countries, while the importations amounted to only 5,690 tons. The exportations of perfumed soaps reached 230 tons in 1920, against 401 tons in 1919 and 24 tons in 1918, and the importations amounted to 739 tons in 1920, against 808 tons in 1919 and 1,549 tons in 1918.

ITALIAN MATCH INDUSTRY

Several of the Italian match factories closed their works after announcing a reduction of wages, made necessary by the reduced demand on the part of the government and by the low profits made on exportations. This led to a meeting, at the Ministry of Industry at Rome, of representatives of the workpeople and of the industry, which is under the direct control of the government. Several discussions have also taken place in the Italian Parliament, but no solution of the difficulty has yet been reached. A new match factory has been started at Turin, which will manufacture exclusively for export. The exportations of matches from Italy in 1920 were 1,033 tons, in 1919 757 tons and in 1918 1,957 tons, but during the first four months of this year they were only 110 tons, against 458 tons for the corresponding months of 1920.



Photo, Underwood & Underwood.

The Seventh National Chemical Exposition

Report of the General Meetings and Technical Sessions of the Exposition, Which Included Symposia on Crushing, Grinding and Pulverizing, Evaporating and Drying, Paint and Varnish, Ceramics, Chemical Power Plants, and American Dyes and Colors

THE Seventh National Exposition of the Chemical Industries was formally opened Monday evening, Sept. 12, with a brief address by Dr. Charles H. Herty. He spoke of the new spirit which is unifying the chemical industries and welding them into a mighty organization, with the single purpose of serving our country in time of peace, or if need arise, in time of war. If the industries are to serve these vital needs, they must be conserved, not alone by the chemist, but by the people acting through their representatives in Congress.

Chemical Progress and Our National Defense

The importance of chemical progress to the national defense was discussed by Senator Irvine L. Lenroot, who is a prominent member of the Committee on Military Affairs of the United States Senate. The Senator has long been a friend and supporter of chemical warfare and has had occasion to observe its progress and development. He declared that the recent bombing tests had convinced him that the airplane, the airplane carrier, the submarine, poison gases and high explosives will be the implements of war of the future. In referring to the work of the coming conference on disarmament, Senator Lenroot said: "We may agree upon a limitation of battleships, a limitation of submarines, a limitation of airplanes, a limitation of armies, a limitation of the quantity of the war material that can be kept on hand, but we cannot agree upon a limitation of brains, and if we could the limitation would be worthless."

He concluded his address with an appeal for continued research and development in order to insure a reserve of chemists and of chemical plants that can be converted to the manufacture of explosives and gases should the need arise.

Preparedness and Chemical Disarmament

General Amos A. Fries, head of the Chemical Warfare Service of the U. S. Army, who followed Senator Lenroot, declared: "There can be no complete disarmament while any country is operating its chemical factories. Therefore each country must develop its resources along chemical lines.

"The world today demands and will have dyes, photographic chemicals, perfumes and medicines. If we do not produce these substances, other nations will, and by the possession of plants for their manufacture, the nations are equipped to produce the most deadly weapons of war." General Fries declared further that disarmament is only an economic measure, not an insurance against international conflagration. "No disarmament treaty could presume to forbid the manufacture of these necessaries of civilized life. Therefore disarmament cannot disarm. It may limit the size of navies, the size and number of guns, but it cannot prevent any nation advanced in the chemical arts from swiftly utilizing its dye plants for the manufacture of destructive gases and explosives."

Protection for the Chemical Industry

That there are Members of Congress who thoroughly realize the importance of the dye industry was clearly demonstrated Tuesday evening in the address of Congressman Fred S. Purnell, of Indiana. The speaker declared that "just as the World War was the means of bringing to the attention of the world the remarkable

achievements of American chemistry, so a calm deliberation will show us our immediate duty. America has taken the lead in the world's chemical industry. That position must be sustained not only as a potential element of preparedness but as a peace measure. The coal-tar industry and the science of chemical warfare are so closely allied that it becomes our paramount duty to protect the dye manufacturer. The military strength of a nation will in the future depend almost entirely upon its dye plants."

In explaining his personal attitude toward the Longworth bill, Mr. Purnell said: "If we are to save this industry we must act now. Being an old-fashioned protectionist, it is not hard for me to advocate a measure of protection which will amount to an embargo. If the industry is not saved now and encouraged as well as fully protected, American capital will never go into it again and world monopoly will be returned to Germany for all time."

The Chemical Industries and the Tariff

The unprecedented interest of the chemical industries in tariff matters was probably responsible for the large attendance at the general meeting, Wednesday evening, when Dr. Thomas Walker Page, chairman of the United States Tariff Commission, delivered an address on "The Chemical Industries and the Tariff." Commissioner Page prophesied that more time will probably elapse between the introduction of the present tariff bill and its final enactment than has been required for any other tariff in a generation. The chemical industry has been acutely disappointed because of this apparent failure of the bill, and perhaps has failed to realize all of the serious difficulties confronting the tariff maker. The first of these is that it has been practically impossible to estimate the competitive strength of many of the war-developed industries. The growth of new processes abroad, such as nitrogen fixation in Germany and synthetic acetic acid manufacture in Canada, has complicated the valuation of our domestic industries. Abnormal costs and prices and the futility of ascertaining foreign costs of production have contributed to the difficulty.

A second cause for delay has been the growing friction between the producers of fininshed products and raw materials.

For example, the highly finished product of the dye industry is regarded by the textile manufacturer as his "raw material." The old fight between farm and factory has changed materially. Agricultural interests, formerly low tariff advocates, are strong in their demands for protection, while many of the Eastern manufacturers who have developed foreign markets for their products are desirous of keeping the rates as low as possible in order not to jeopardize their export trade.

Two other difficulties which add to the tariff maker's problem are the need for accepting goods in payment for foreign debts, and confusion arising from the chaotic condition of foreign exchange.

Commissioner Page discussed the many new features of the tariff bill passed by the House and pointed out the use made by Congress of the information supplied by the United States Tariff Commission. He also took the opportunity to refute in public the statements of Congressman Frear that the Tariff Commission had released its 1920 census of dyes in order "to bolster up this dye provision," and that the release of the report had been "timed exactly by the commission, which wants the power, which wants the $100,000 and which is insisting that they are the ones to determine what shall be imported and what shall not." Dr. Page declared that the legislator was hopelessly mistaken in his accusations, for "the Tariff Commission has at no time sought the administrative powers of the various dye bills, but has consistently discouraged Congress from placing such duties upon it, since the Tariff Commission is essentially an informative body and not an executive one."

Crushing, Grinding and Pulverizing Symposium

The subject was introduced by Harry J. Wolf, chairman. The three words, crushing, grinding and pulverizing, he said, have been assigned special technical meanings, which in one sense refer to a general classification of the mineral fragments as to size, and in another sense to the manner in which they are reduced, or to the motion of the parts of the machine designed to accomplish the reduction. He then reviewed briefly the status of the art of crushing, and called attention to some of the more prominent recent advances.

Crushing, Storing and Pulverizing.—L. H. Sturtevant of the Sturtevant Mill Co. in a paper on "Crushing, Storing and Pulverizing" said that during the last decade crushing and pulverizing machinery has become highly specialized, and no longer is the "all-purpose" machine recognized in the modern plant. It has been found that machinery embodying certain principles is necessary to produce certain results, and by deviating from these principles inefficiency and a high-cost product, if not failure, are sure. He then discussed the nature of the materials to be handled, and the machinery and equipment used especially in connection with the phosphate rock industry.

Grinding and Pulverizing With Air Separation—F. B. Kanowitz of the Raymond Bros. Impact Pulverizer Co. presented a paper on the subject "Grinding and Pulverizing With Air Separation." The author discussed the subject at length, and presented a most complete detailed and exhaustive review.

Dust Collection as Applied to Grinding and Pulverizing Problems.—M. I. Dorfan of the Allis-Chalmers Manufacturing Co. delivered an illustrated lecture on the subject of dust collection as applied to grinding and pulverizing problems. He said that for the solution of a dust-collecting problem there are important facts which must be known before the problem can be handled, and they are briefly as follows: 1. The number and kind of dust producing machines. 2. Their relative location. 3. The quality and character of dust to be handled. 4. The condition and quality of the air or gas carrying this dust. Particularly must be mentioned the amount of moisture present in the air, gas or dust. With the above and a layout of the plant in question, the dust-collecting engineer can determine what will be required in the way of dust-collecting machinery to overcome the problem that exists. He must then determine for himself what velocities will be required to convey the various dusts, what type and size of piping had best be employed, and what type and kind of collector would give the operator the results sought.

Development of Compound Grinding Mills.—H. Schifflin's paper on the subject "The Development of Compound Grinding Mills" was presented by Theodore Pilger. This paper was illustrated by numerous lantern slides indicating the development and design of the com-

pound grinding mill. Following this paper Mr. Abbe stated that the compound mill was introduced by the Abbe Engineering Co. sixteen years earlier than the date claimed for its introduction by the Allis-Chalmers Manufacturing Co., and that the latter company could not claim the credit for having introduced the mill. Mr. Abbe promised to write a letter setting forth the claim he made.

There followed a short talk by Dr. H. H. Dow on the subject of the tariff in its relations to the dye industry, in which he called attention to the desirability of protecting the American dye industry just long enough for it to demonstrate its ability to take care of itself, which, he assured the audience, could be done.

Of the papers which were to be presented on the subject of Industrial Problems only the paper of H. Austin (Ernest Scott & Co.), on "Solvent Extraction on Edible Fats and Oils," was read and as the clock registered 6:15 p.m. there was no time to proceed with the other papers on the program—namely, those by R. H. McLain of the General Electric Co. on "Material Handling in Industrial Plants," and by W. H. Dickerson, of Industrial Waste Product Co., on "Utilization of Industrial Waste; Its Economic Importance."

The chairman made the recommendation to the manager of the exposition, that in outlining all future programs of this character the speakers be positively limited to a fixed number of words or a fixed time available for the presentation of their subjects, so that a large proportion of the time available could not be monopolized by any one speaker. Naturally some of those in attendance come a considerable distance to hear a discussion on a certain subject or to listen to a certain paper, and they are disappointed when the program must be curtailed on account of insufficient time.

Evaporating and Drying Symposium

The symposium on evaporation and drying was held Wednesday, Sept. 14, under the chairmanship of Wallace Savage. In the opening address Mr. Savage said that there are about sixty machinery manufacturing companies producing around two hundred designs of evaporating and drying equipment in this country. One-half of these devote their attention exclusively to driers and one-third to evaporators. About twelve companies produce both. This afternoon we have the pleasure of hearing a number of 15-minute talks giving the basic ideas involved in the leading types of equipment for transforming liquids to vapors and in this form displacing them from solutions or solids, either by air currents or vapor pumps.

Selection of Drying Equipment

H. S. Landell, of Proctor & Schwartz, was to present a paper on Drying and Drying Problems, but instead spoke on the understanding and confidence that should exist between a prospective purchaser and the manufacturer of drying equipments. He said that it is always to the purchaser's interest, especially when a new plant is being built, to consult with a reputable drying concern before his plans are all made. Often he thinks of his drying as an incidental process which can be placed anywhere, not realizing that frequently his drying is one of the most important problems. The best way for the prospective purchaser is to give the drying salesman a generous, representative sample of the material to be dried, and at the same time give him all the information possible regarding the preliminary and supplementary operations. Drying tests will be run on the material furnished, and the drier manufacturer will then be able to submit a proposition for a drying equipment that will be guaranteed both mechanically and as to capacity.

Special Problems for Enameled Evaporators

Max Donauer, of the Elyria Enameled Products Co., in speaking about the special evaporation problems, described briefly the two common types of enameled evaporator—namely, jacketed evaporating dishes and single-effect vacuum pans—and enumerated a series of industries where enameled evaporators are the most appropriate. "The field of enameled evaporators," he said, "is for the most part a special one. It includes those operations in which the presence of an enameled surface plays an important part. Thus enameled evaporators are used for concentrating solutions which contain acids and for preparing products which must be kept free from contamination. The uniform heating conditions make enameled vacuum pans suitable for concentrating sensitive products which are apt to discolor or become caramelized. Enameled surfaces can be readily cleaned, and this makes the evaporators very suitable for food and drug work. Indeed, in the preparation of many of the highest grade food and chemical products, enameled evaporators play an important part."

Drying With Moist Air

Arthur B. Stonex, of the Hunter Dry Kiln Co., in his address on Drying With Moist Air said in part:

"To those not intimately familiar with certain forms of present-day industrial drying the title of this paper, 'Drying With Moist Air,' may seem in the nature of a paradox, a contradiction of terms, for obviously moisture is the antithesis of dryness, and so to dry with moist air may at first blush seem as preposterous as to refrigerate with warm air. But drying with moist air will not seem quite so insane a procedure when it is remembered that in nature one never finds air that is not moist, and every one knows that a vast amount of drying, as of the soil and vegetation, is constantly going on. Indeed in many industries where the drying of materials or finished products is necessary so-called natural drying is regarded as the ideal kind of drying.

"Moist air is so desirable for drying at least some materials that it is artificially produced. The principle governing this practice is that the increased absorptive capacity of the air is only indirectly due to the increased temperature—that is, the increased capacity is rather the result of the decreased degree of saturation of the air. The solution of the problem, therefore, is to find for a given material not the maximum temperature, but the minimum degree of saturation or relative humidity at and above which too rapid surface drying will not take place at the highest temperature the character of the material and profit will otherwise permit, and to maintain that temperature and, as long as necessary, that relative humidity.

"By raising the temperature, the vaporization of the water in the material is hastened, but by keeping the relative humidity of the air sufficiently high, the air will not absorb the vapor coming from the surface of the material any more rapidly than at a lower temperature. Indeed, with certain materials it is desirable, and with proper humidity control it is possible, to prevent any surface drying until the stock has be-

come uniformly and sufficiently warm and vaporization has begun throughout the mass. In general it may be said that besides the prevention of destructive surface drying, the maintenance of such relative humidity results in more uniform drying of any material, and that the effects of any temperature above 100 deg. appear to be less severe in a comparatively moist air."

Drying as an Air Conditioning Problem

A. W. Lissauer, of W. L. Fleischer & Co., Inc., in his address on Drying as an Air Conditioning Problem, brought out the fact that drying is still supposed by many to be the simplest branch of all heating and ventilating and that failures are accredited consistently to circumstances which probably have no bearing. He stated that the phenomenon of drying can be explained very easily by the application of the law governing air conditioning—in other words, drying is merely air conditioning—and concluded by saying that the solution of any drying problem which has for its object the obtaining of the highest quality of product with the maximum efficiency can be accomplished if guesswork is eliminated and painstaking study and experimentation be substituted.

Criss-Cross Evaporator

A new type of tube evaporator deriving its novelty from a decidedly different tube arrangement was described in an interesting paper on the Criss-Cross Evaporator by Robert V. Cook, chemical engineer and sales manager for the Chemical Equipment Co. The new evaporator is known as the Criss-Cross because of the cross-arrangement of its tubes. This is clearly shown in the accompanying cross-section drawing. It will be seen that the rectangular liquid chamber carries the crossed tubes and the steam chests. The front steam chest is divided in the center by a horizontal partition, so that the steam must descend down the tubes inclined toward the bottom of the back steam chest. That part of the steam which has not been condensed then rises and descends in the opposite direction toward the bottom part of the front steam chest. The condensed steam is drained out of the bottom of both front and back chests. The top of the evaporator, or the vapor chamber, is a cylinder with a vertical axis and has several times the volume of the liquor chamber. This allows the vapor to slow down, to expand and to drop out the entrainment. A standard save-all is employed to make sure that no liquid will be drawn out along with the vapor. In this particular evaporator there are ninety-six ½-in. seamless drawn copper tubes, 32 in. long, giving 33.5 sq.ft. of heating surface. They are arranged in two groups, half being inclined downward toward the right and half inclined downward toward the left, the rows being staggered, as shown.

Mr. Cook explained a number of advantages claimed for the new evaporator and referred to the possibility of applying the same principle to preheaters, boilers, surface condensers and different forms of heat-exchange apparatus.

Vacuum as Applied to Industry

James S. C. Chen, of the J. P. Devine Co., spoke on Vacuum as Applied to Industries. He said that vacuum drying, which was used only in limited fields in the past, has in recent years attained a position of such importance in the chemical and allied industries that it is worth while to make a thorough and comprehensive study of the subject. At present vacuum drying is extensively used in the chemical and allied industries not only because its use is in many instances imperative, but because its use is efficient, economical and insures superior and uniform quality of the finished product. Vacuum drying has found extensive application in the drug and dye industries and in drying fruits, vegetables and dairy products. His closing remark was that no modern industry can long prosper or even survive without giving constant attention to the improvement of its method of production and refining and to the quality of its products.

Atmospheric Drying: Compartment, Tunnel and Continuous Belt Conveyor Driers

Jerome D. Stern, of Grinnell Co., Inc., Drier Division, summarized his address on Atmospheric Drying by Means of Compartment, Tunnel and Continuous Belt Conveyor Driers, With Some Practical Applications, by saying:

"The physical and chemical characteristics of the wet and dried product are the primary factors in deciding on the proper type of drying equipment to install. The most efficient method of handling the material, the air temperatures, volumes, velocities and humidity are all dependent on this deciding factor, and unless one has wide experience with the nature and conditions of the product, or as a result of thorough and exhaustive laboratory tests, it is a waste of time to make any calculations or recommendations until these are absolutely determined."

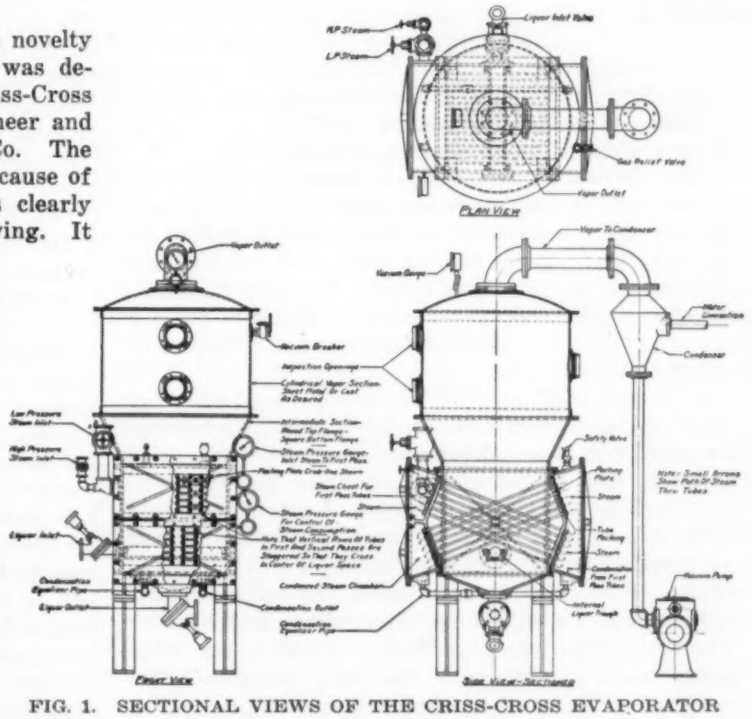


FIG. 1. SECTIONAL VIEWS OF THE CRISS-CROSS EVAPORATOR

Evaporation

H. Austin, of Ernest Scott & Co., presented a paper on Evaporation in which, after reviewing the various problems pertaining to evaporation and to the selection of an appropriate evaporator, he outlined some of the

characteristics of the Scott evaporators. He concluded by saying:

"'Evaporation' is in effect 'distillation,' and in the distillation of oils in which different fractions separate at a known fixed temperature and vacuum, evaporators using steam heat may, with advantage in cost of outfit and operating costs as well as more easy control, be used instead of ordinary type stills using fire heat. Benzine, gasoline, naphtha, etc., can, with advantage, be evaporated, distilled and fractionated in machines similar in design and construction to those more commonly associated with the evaporation of water."

Paint and Varnish Symposium

Thursday, Sept. 15, was Paint and Varnish Day and the well-arranged programs attracted large audiences. The afternoon technical session was followed by a popular meeting in the evening on the theme, "Save the Surface and You Save All." Ernest T. Trigg, chairman of the "save the surface" committee, Paint Manufacturers' Association of the United States, acted as chairman and delivered a most interesting address on the aims and accomplishments of this campaign.

At the paint and varnish symposium, which was presided over by R. S. Perry, the following papers were presented:

Laboratory Control

Scientific control of paint and varnish manufacture was discussed by Leo P. Nemzek, of E. I. du Pont de Nemours & Co. He spoke in part as follows:

While laboratory control has its most direct association with production, there are many points of contact with the sales department. Successful operation is measured largely by the contact with sales, and through them with the ultimate consumer. The paint technologist must know what the consumer requires from a point of service, and what he desires from a decorative point of view.

The handling of complaints offers one of the best avenues of sales department and laboratory co-operation. Nine out of ten complaints are due either to paint improperly applied as to time, surface condition, or workmanship, or else the proper paint was not selected for the job. Yet in the handling of a complaint, there is an excellent opportunity for displaying much tact and patience, besides bringing out all of the recorded facts and information available on the subject involved.

The major function of laboratory control is associated directly with production. The first requisite is a thorough knowledge of the products in which the different raw materials are used. A raw material record should be maintained, which immediately shows all products in which a particular material appears. This record is necessary in raw material development work, in advising the works where certain shipments of raw materials may be used to best advantage. The record is essential in the adoption of raw material substitutions which are occasionally necessary.

Laboratory control must exercise a close check on new formulations. This may be a part of control work, or merely come under the general supervision of the chief chemist. A properly kept products index will help to keep down the formulation of new paints. Such an index shows in a moment a list of products of the same character or similar nature to the material under consideration.

The greatest value of the index lies in the standardization of formulas. All products of a certain type should be composed of the same ingredients. A thousand enamel formulas will vary only in the pigments necessary to give desired colors. The vehicle will consist of half a dozen standard varnishes, and not twenty or thirty, which might very easily be the case if standardization of formulas is not watched.

This holds true for ready mixed production, but the situation is reversed when it comes to pastes. Then the practice is not economy. There are cases where the use of two or three standard bases in producing a paste product means increasing the cost 10 to 15 per cent over what it would be if the formula ingredients were put together separately.

Laboratory control requires first of all a thorough knowledge of:

1. The user's requirements of the paint and varnish.
2. The chemical and physical properties of available raw materials. How they react one with another, and what different combinations develop on aging.
3. Possessing the first two requirements: control or supervision over the formulation of the most economical product that will give satisfaction.

Development work is essential both on raw materials and finished products. The field for research is large. The work that should be done is suggested by the conditions that arise in the usual routine functioning of technical control. The strictly routine functions of laboratory control are the checking of all raw material shipments and finished products so as to insure uniformity.

Reflection Factors of Industrial Paints

Dr. Henry A. Gardner presented a paper on reflection factors of industrial paints and pigments.

In computing the reflection factors of industrial paints, the factor 0.98 should be used for magnesium carbonate (the standard) rather than 0.88, and earlier measurements should be corrected accordingly. For instance, the reflection coefficient of a white paint which previously may have been reported as 76 should be corrected to read 85. The possibility of having walls in factories so painted that they yield by reflection 85 per cent of normal light is of great importance to the architect and owner. Figures for a few industrial flat and gloss paints now marketed are given in Table I. It will be noted that some of them run as high as 82 per cent, a figure extremely high in comparison with similar type paints marketed several years ago. This great advance in the production of interior industrial whites of high illuminating value has come as a result of many years of careful study and selection of the pigments and liquids available for the purpose.

TABLE I. REFLECTION FACTORS OF MODERN INDUSTRIAL WHITE PAINTS

	Coefficient of Reflection*		Coefficient of Reflection*
Exterior white oil paint	71	Gloss mill white XX	76
Non-darkening exterior oil paint	78	Gloss mill white XXX	82
Gloss mill white X	74	Flat mill white	76

* On basis of 98 for magnesium carbonate.

White paints may show a small loss of reflection value after remaining in a dark place for several years, due to yellowing of the oil content. This loss, however, is probably much less than would occur when paints become darkened due to dust adherence, even over a short period

of time. For the walls and ceilings of factories a paint is desired that will initially and permanently give the highest degree of reflection. Off-color products or those that show rapid yellowing of the oil content are considered unsatisfactory. Tinted and colored paints may or may not show a loss in reflection value upon aging. The result will vary with the type of tinting color used.

White opaque pigments vary in reflection value. It would appear that the greatest reflection is obtained from pigments with the greatest opacity.

For determining the reflection factors of industrial paints, it is suggested that two coats be applied under standard conditions to black iron surfaces previously coated with a continuous coat of flat black primer. For this purpose, the same amount of each paint should be applied, as determined by weight of paint applied.

An example of the results obtained by this method will be found in Table II. In this series of tests, the pigments were ground in a liquid consisting of one part of flatting varnish and two parts of turpentine. The paints contained 60 parts by weight of pigment and 40 parts of liquid, since it was impossible to make a workable paint with over 60 per cent of certain of the pigments employed. Two heavy brush coatings were applied to a series of sheet-iron panels, one hour being allowed between coats. The panels had previously been coated with a perfectly black, flat paint having a reflection coefficient of about 5. The great hiding power of the opaque white pigments was at once evident from the appearance of the finished panels. The inert pigments, on the other hand, had but little hiding power, in comparison.

TABLE II. REFLECTION FACTORS OF CERTAIN WHITE PIGMENTS

Pigment	Coefficient of Reflection When Applied in Flat Liquid	Coefficient of Reflection, Compressed Dry Pigments
Lithopone (A grade)	81	91
Titanium pigment	78	91
Zinc oxide (French process)	78	91
Zinc oxide (5 per cent lead)	77	87
Lithopone (Grade B)	69	89
White lead, Type A	67	....
White lead, Type B	50	90
Calcium carbonate	38	....
Silica	19	....
Barium sulphate	13	88

For comparison, the reflection factors of the dry pigments are given in the second column of Table II. It should also be borne in mind that the hiding power of a paint depends largely upon the liquids chosen for the vehicle portion. The greater the difference between the refractive index of a liquid and that of the pigment the greater will be the hiding power of the paint.

This paper by Dr. Gardner has been published as Circular No. 133, Educational Bureau, Paint Manufacturers' Association of the U. S.

Physical Testing of Paints

Frank G. Breyer, of the New Jersey Zinc Co., called attention to the fact that the physical testing of paints and paint materials has not received attention commensurate with its importance. He made a plea for a rational development program for paint technology based on five fundamental factors—suspension (mixing or incorporation), life of suspension, application, conversion of applied material to adherent film and life of film.

Paint and Varnish Waste Control

R. S. Perry's paper on "Paint and Varnish Waste Control" was read by his associate, Paul Webster. The fume recovery process developed by this firm has been described in CHEMICAL & METALLURGICAL ENGINEERING, vol. 23, p. 771, Oct. 20, 1920, and many of the views shown by Mr. Webster were included in that article. Other installations described and illustrated by Mr. Webster were those of the Patton-Pitcairn Division, Pittsburgh Plate Glass Co., Milwaukee, Wis., and Breinig Bros., Inc., Hoboken, N. J.

The Ideal Paint and Varnish Specification

F. P. Ingalls' paper on "The Ideal Paint and Varnish Specification" will be found in full on page 595 in this issue.

Limitations of Standardization

The limitations of standardization of paint and varnish manufacture were considered at some length by D. A. Kohr, of Lowe Bros. Co. He said in part:

Very few of the products of the paint maker are made on absolute formulas; it has even been said that paint formulas serve merely as guides, and in a large measure this is true, because almost every batch of paint must be modified by the addition to it of small quantities of this, that or the other raw material before the batch is ready to pass final inspection. Accordingly most paint manufacturers have learned by experience to pay scant attention to the applicant for a position who shows as his chief recommendation a collection of someone's formulas. Almost anybody can mix together raw materials in accordance with a formula, but before the resulting mixture can pass muster as a paint of quality it must be given the careful attention of an experienced paint maker.

The same raw materials from the same sources of supply, as they are furnished to the paint maker, will not when made into a paint always produce a product that has the same properties—in fact, the resulting product is much more apt to vary than it is to be uniform. The consumer expects different lots of the same paint to be uniform and when the difficulties overcome are considered, different lots of the same paint from a reputable manufacturer are wonderfully uniform; but their chemical composition is not uniform within close limits and, if best results are to be obtained, it cannot be made uniform.

The paint and varnish industry differs from the automobile industry, for example, in an important respect. Whereas the automobile manufacturer turns out a product that is ready for the ultimate consumer to use, the products of the paint and varnish maker must first be applied by a painter or finisher to some surface owned by the consumer, and then be allowed to undergo the chemical and physical changes commonly known as drying and hardening before they can fulfill their real purpose. Hence what the paint and varnish manufacturer is actually furnishing the consumer is not paint and varnish, but beautification of his property, as when a piano is beautifully stained and varnished; or protection to his property, as when an expensive bridge is painted to prevent corrosion of the steel; or both, as when a man has house paint applied to his own residence.

A vast amount of work has been done by many manufacturers in designing a fairly large number of excellent products which when intelligently used will give fine results. Is it therefore not reasonable to suggest that consumers who certainly know less about paint making than paint manufacturers will more quickly

bring about the desired end of securing uniformly good results from painting, if they turn their energies from the question of standardizing the composition of paint and give more attention to the control of those factors that have an influence on the final result equal to that of the paint and which are entirely beyond the control of the manufacturer? When a consumer is sure that paint is applied only to clean, dry, warm surfaces under suitable weather conditions, and by mechanics who are fully competent and experienced, then, and only then, can he profitably consider whether he can specify a paint that will be better than the one offered by a reputable manufacturer as the result of his long experience and observation under many varying conditions.

American Ceramic Society Meeting

The American Ceramic Society meeting was held Friday, Sept. 16. Among the papers presented were the following:

Business Conditions Relating to the Clay-Working Industries.—John G. Jones spoke on the outlook for the clay products industry. The chief problem at the present time is to fix prices at a level which will appear attractive to customers. A clear statement is needed of the difficulties in the way of reducing prices. The cost of fuel is still 100 per cent above the pre-war level owing to the fact that the wages of the coal miners have not yet been reduced. Freight rates are still high. Materials used in manufacture have not declined in proportion to the rest of the commodity list. It is not difficult for steel mills to cut wages, because they are dealing with common labor, poorly unionized. Clay producers, on the other hand, must deal with skilled workers, highly unionized. For these reasons the present price of clay products is not unreasonable. There has been a reduction of 40 per cent from the peak prices. The approaching demand in many lines promises a revival of trade near the present price levels during 1922.

The Importance of Chemical Stoneware in the Chemical Industries.—Percy C. Kingsbury said that although chemical stoneware is a small branch of the ceramic industries, it is of great importance to chemical plants. No stoneware body can meet all the varied requirements of the chemical industry, and it is therefore necessary to furnish a wide range of stoneware products from the firebrick-like mass at one extreme to the porcelain-like mass at the other. Chemical stoneware is unaffected by any of the products met with in industrial chemical work, with one or two relatively unimportant exceptions. The glaze serves only to give the ware a smooth surface and does not add to its acid-resisting properties.

The Passing of King Methane.—S. R. Scholes, in speaking of the depletion of gas in the clay districts, said that forty years ago natural gas, which is chiefly methane, was regarded as a nuisance encountered in drilling for oil, but it became the most important glass-house fuel, and its abundance and excellence gave rise to the prosperous glass industry of the Ohio Valley. It has been wastefully used, and is now so scarce and expensive, especially in cold weather, that other fuels such as producer gas and fuel oil are replacing it. Even in the best glass-melting tank furnaces, less than 10 per cent of the heat of the fuel finds its way into the glass; 20 per cent goes up the stack and 70 per cent is lost by radiation. With the present refractories this high radiation loss cannot be stopped by heat insulation, because of the consequent melting or failure of the refractories. These must be improved so as to bear insulating. Also there must be better engineering work done on designing furnaces for the best heat economy, so that the successors of "King Methane" need not be burned with the same prodigality that has wasted our resources of natural gas.

Porcelain for the Laboratory.—Charles F. Binns defined porcelain for the chemical laboratory, for it differs from china, even though both are white and translucent. He described its origin and method of manufacture. It was produced in common with most ancient wares by a reducing fire, involving a refractory glaze. Methods of production in America and Europe were compared. Mixture of porcelain glaze was contrasted with lime-soda glass and mixtures of chemical porcelains were compared with china and earthenware.

Heavy Clay Products Research.—Maurice B. Greencugh of the National Paving Brick Manufacturers' Association and secretary-treasurer of the Joint Clay Products Research Committee spoke on heavy clay products research. The Federal Government through its bureaus, the scientists of the clay products industry through the American Ceramic Society and the manufacturers of facebrick, hollow building tile, common and vitrified paving brick through a joint committee of their respective national associations have all joined hands to seek by research to solve vital problems in heavy clay products production. The scope of work has been defined and assignments have been made to each group. The financial support is assured and the program is in operation. The program differs materially from the general run of such efforts. In the first place, the public is represented and has an interest exercised through the work that is being done in the Government bureaus. The buyer co-operates with producer in the improvement of processes and the bringing about of more economical industrial operations. The operations of the program are beginning with studies of existing equipment. Present kiln types must be employed with greater efficiency. Practical considerations are foremost in promoting the studies. The preliminary stages of the whole organization are passed and nothing but hard work lies between the present and the ultimate attainment.

The conference on the program of the American Ceramic Society activities held at the Hotel Commodore Sept. 15-17, will be reported in a later issue of CHEMICAL & METALLURGICAL ENGINEERING.

Symposium on the Power Plant in the Chemical Industries

The Symposium on the Power Plant in the Chemical Industries was held Friday afternoon under the chairmanship of R. C. Beadle, editor of *Combustion*.

Mr. Beadle in his opening address brought out the facts that about 10,000,000 tons of coal is used yearly by the chemical industries and that by the introduction of mechanical coal firing the fuel efficiency has increased to about 85 per cent from an efficiency of only about 50 per cent with hand firing. He predicted that before many years have passed the fuel used in the chemical boiler plants will be a byproduct of the raw coal.

Description of a Modern Boiler Plant and Equipment.—R. M. Gordon, manager of the steam supply and testing departments of the Solvay Process Co. at Syracuse, N. Y., gave a detailed illustrated description of the

water purification, coal preparation and boiler house at the Solvay Process plant, where all the principal operations are metered or recorded so that the efficiency of the plant can always be calculated and is figured and charted each month. Daily outputs are carefully watched. The efficiencies for the past six months are as follows:

	Per Cent
Boiler and furnace	77.5
Boiler, furnace and economizer	82.2
Plant efficiency	85

How Heat Losses in Chemical Plants May Be Reduced.—John Primrose, vice-president of the Power Specialty Co., of New York, spoke on how heat losses in chemical plants may be reduced. He said in part: Modern engineering practice has recognized the importance of good combustion, and means are now available for more completely burning the fuel before attempting to recover any of the heat produced by combustion. After the fuel is properly burned, the next consideration is to absorb the heat produced.

Of all methods of supplying heat in process work probably the most economical is heating by saturated steam where the steam is condensed and the resulting hot water is returned to the boiler. This is limited to processes that do not require a temperature higher than is available with saturated steam, say, 300 deg. F. Above this temperature, up to 600 deg. F. or higher, superheated steam may be used, and if the steam can be used in turbines or pumps, etc., after it has served its purpose as a heating medium and the exhaust is used in heating feed water, the economy is almost as good as with saturated steam. Each individual problem is worthy of study by engineers, not necessarily chemists, but who by training and experience have obtained knowledge of heat engineering beyond that usual in the chemical industry itself. Such studies, it is reasonable to expect, would bring about that very much desired result—a reduction in manufacturing cost.

Compressed Air Installations in Industrial Plants.—A. R. Stevenson, Jr., of the power and mining engineering department, General Electric Co., spoke on compressed air installations in industrial plants. He outlined the appropriate uses for single- and multi-stage centrifugal compressors, rotary displacement blowers and reciprocating compressors. In almost any chemical plant there are liquids to be moved. Compressed air is used extensively for such pumping. He touched on the three fundamental systems in use—namely: 1. Air lift, 2. Pneumatic displacement pump, 3. Return air system, and stated that these three systems are especially good for dye works, bleacheries, pulp mills, and for handling solutions, because there are no moving parts, lubrication or packing and they are therefore not affected by muddy or gritty water.

Application of Electric Power in the Chemical Industries.—The paper on the application of electric power in the chemical industries, by D. B. Rushmore, J. A. Seede and E. Pragst, of the General Electric Co., consisted of a lengthy discussion of the uses of electricity in electrothermics, electrolysis, for transformation into mechanical power and in the specialized applications such as magnetic and electrostatic treatment, ultra-violet rays, X-rays and others of small application but great possibility.

After passing in review the field of electrothermics, the sources of primary power and the problem of purchased power versus isolated plants, they outlined at length the practice in steam-electric and hydro-electric generating stations and concluded as follows:

"The chemical industry is at present one of the most fruitful fields for electrical application in the future. It is fruitful not only from the point of view of those engaged in the manufacture and sale of electrical apparatus, but particularly from the standpoint of pure engineering, for it is forever presenting to the electrical engineer problems of a most diversified interest—problems ranging from heavy currents at low potentials to the opposite conditions of low current at high potentials, with alternating and continuous current; problems where the frequency ranges from 5 cycles to 10,000 cycles per second; problems involving X-rays, ultra-violet rays and other means of accelerating reactions; problems of insulating materials to withstand the effects of heat, corrosive gases and acids; problems involving the maintenance of continuity of service and the low cost conversion of energy; problems of processes and methods, etc. It is this diversity of interests of the industry, its problems and the rapidity with which it is expanding, that makes it appeal so strongly to the electrical engineer as an outlet for his productive efforts. Obviously the greatest advance will be made when the co-operation is most complete between the chemical and electrical engineer and, as the former has solved many difficult situations for the latter in the past, the electrical engineer will continue to reciprocate, especially along those lines that will materially assist in promoting our national well being."

The Limitations of Silent Chain Drive.—Some general and specific data on the design and use of silent chain drives were presented by F. G. Anderson, of the Morse Chain Co. He stated that the silent chain drive has gradually won on its merits until it is now generally considered by competent engineers a standard drive for practically all of the ordinary power transmissions between parallel shafts and gave as definite reasons: Reliability, positive speed ratio with flexibility of operation; possible short center distances, minimum attention required, high efficiency and quiet running.

Pulverized Coal in the Power Plant.—H. G. Barnhurst, of the Fuller Engineering Co., spoke on pulverized coal in the power plant. He said that the use of pulverized coal in preference to grate firing presents the following advantages: Higher efficiencies are obtainable. The reliability of the plant is increased by the much greater range of fuel which may be satisfactorily burned. Labor is greatly reduced and control of boiler operation simplified. Considerable economies are present in the elimination of standby losses and loss of carbon in the ash, and the boiler flexibility is increased very considerably. The use of pulverized coal in chemical and metallurgical furnaces is gradually becoming a standard method of fuel firing.

Other papers on the program were:

"Boiler Feed Water Treatment and Treatment Control," by E. C. Bashore of Rice & Bashore; "A New Method for Coking Coal as Required for Industrial Fuel," by D. S. Chamberlin, of the Distillation Industries, Inc.; "The Application of Pulverized Fuel," by H. D. Savage, of the Combustion Engineering Co.; "The Prevention of Internal Corrosion in Pipes, Tanks, and Other Iron and Steel Equipment," by Perry West, of the Anti-Corrosion Engineering Co., and a short talk on "The Master Key Industry," by Dr. Charles L. Parsons, secretary of the American Chemical Society.

Is There an American Dye Monopoly?*

BY FREDERICK E. BREITHUT

MANY good Americans are of the *opinion* that there is a monopoly in the dye-making industry.

What are the *facts?*

The accompanying maps show:

1. In 1914 there was no real dye manufacturing in the United States—simply seven small plants in three states, assembling German intermediates into dyes.

2. In 1920 there were eighty-two American dye plants located in eighteen states.

3. In 1920 there were 213 coal-tar chemical plants located in twenty-five states.

1914—Total, 7 1920—Total, 82

LOCATION AND NUMBER OF PLANTS MAKING COAL-TAR DYES IN THE UNITED STATES

In this connection it may be interesting to submit two quotations from official Government reports.

The first is from "Artificial Dyestuffs Used in the United States," by Thomas H. Norton, Department of Commerce Special Agents Series 121, published in 1916:

"The manufacture of coal-tar colors in the United States has been in existence about thirty-seven years. Prior to 1915 it had never become a factor of importance in supplying the American market. The American manufacture was confined almost entirely to the 'assembling' into finished dyes of coal-tar intermediates imported from Europe, chiefly from Germany. In its entirety it represented less than one-tenth of the activity to be encountered in any one of the larger companies producing synthetic dyes in Germany and Switzerland."

Contrast this picture of national dependence with that presented by the following quotation from the United States Tariff Commission's Census of Dyes and Coal-Tar Chemicals, 1920:

"The total number of firms engaged in the production of coal-tar products in 1920 was 213, while those companies engaged in the manufacture of dyes alone numbered 82."

The Tariff Commission has made a study of the number of firms producing each dye, which reveals significant facts concerning the organization of the domestic industry. Three hundred and sixty separate dyes were manufactured in 1920. Of these, 108 dyes, the output of which represented more than 90 per cent of the total production, were *each* manufactured by three or more firms. Of greater importance, however, is the fact that those dyes, representing over one-half of the total quantity produced (thirty-five in number), were *each* manufactured by seven or more firms.

Even a cursory glance at the figures in Table I reveals:

1. That the number of independent manufacturers of each of these large-tonnage dyes is sufficient to deny the existence of a monopoly.

2. In general, prices have shown a steady downward trend (of course there are a few specific instances in which other factors, such as rise in raw material costs and imperfections in process control, make this general tendency inoperative).

What about the intermediates from which dyes are made? Let us begin with a specific example. You are all familiar with the substance known as naphthalene. It is commonly used in the form of moth balls. This commodity is one of the most valuable of coal-tar chemicals. According to the 1920 census there were forty-six important intermediates made from this coal-tar crude. The number of manufacturers producing each of these commodities is indicated in the following table:

Name	No. of Mfrs.
2-Naphthol-3:6-disulphonic acid	16
1-Amino-2-naphthol-4-sulphonic acid	13
1-naphthylamine-2-sulphonic acid	12
1-Amino-8-naphthol-3:6 disulphonic acid	12
2-Naphthol-6:8-di-sulphonic acid	9
Naphthalene, solidifying 79 deg. C., or above	9
1-Naphthol-4-sulphonic acid	8
2-Naphthol-6-sulphonic acid	7
2-Amino-8-naphthol-6-sulphonic acid	7
1-Naphthylamine-3:6:8-trisulphonic acid	7
2-Naphthylamine-6:8-disulphonic	6
β-Naphthol, tech	6
1-Naphthylamine-5-sulphonic acid	5
2-Naphthylamine-1-sulphonic acid	5
α-Naphthylamine	4
1-Naphthylamine-8-sulphonic acid	4
1:8-dihydroxy naphthalene-3:6 disulphonic acid	4
1-Diazo-2-naphthol-4-sulphonic acid	4
Phthalic anhydride	3
α-Naphthol	3
Phenylalphanaphthylamine	2
Nitronaphthalene	2
β-Naphthylamine	2
1-Naphthylamine-6-sulphonic acid	2
2-Naphthylamine-6-sulphonic acid	2
1-Naphthol-5-sulphonic acid	2
1-Naphthol-3:6:8-trisulphonic acid	2
β-Naphthol, U.S.P.	2
2-Naphthol-7-sulphonic acid	2
2-Naphthol-8-sulphonic acid	2
1-Amino-8-naphthol-2:4-disulphonic acid	2
8-Nitro-1-diazo-2-naphthol-4-sulphonic acid	2
Phthalamide	2
Chrononaphthalene	1
Ethylbetanaphthylamine	1
Naphthalene 2:7 disulphonic acid	1
1-Phenylnaphthylamine-8-sulphonic acid	1
1-Tolylnaphthylamine-8-sulphonic acid	1
1-Naphthylamine-3:8-disulphonic acid	1
1-Naphthylamine-4:8-disulphonic acid	1
2-Naphthylamine-4:8-disulphonic acid	1
2-Naphthylamine-5:7-disulphonic acid	1
1-Naphthol-3:6-disulphonic acid	1
2-Naphthol-5:7-disulphonic acid	1
Dioxynaphthalene	1
1-Chloro-8-naphthol-3:6-disulphonic acid	1

*A paper presented at the Seventh National Exposition of Chemical Industries, Eighth Coast Artillery Armory, New York, Sept. 12-17, 1921.

If you will glance through the pages of the Tariff Commission's report, you will find that the case of naphthalene is typical of the whole list of coal-tar chemicals produced in our country. This is made

TABLE I. DATA ON LARGE-TONNAGE DYES

Schults No.	Name	Total Production, 1920	No. of Mfrs., 1920	Average Price per Lb. 1917	1918	1919	1920	Aug. 25, 1921
23	Tartrazine	701,722	5	....	....	....	$1.86	$1.30
33	Chrysoidine Y	585,648	7	$1.09	$0.77	$1.04	.87	.75
82	Ponceau 2R	1,286,002	8	1.15	.79	.80	.80	.60
134	Metanil yellow	629,437	6	....	....	1.65	1.64	1.10
145	Orange II	1,850,341	12	.98	.68	.63	.62	.45
181	Salicine black U	1,074,248	14	....	1.62	1.25	1.10	.60
217	Algama black 10B	2,608,864	16	....	1.26	1.47	1.29	.85
283	Bismarck brown	514,218	11	1.17	.81	1.01	.84	.70
307	Congo red	1,502,630	5	....	2.01	1.12	.86	.60
333	Oxamine black BHN	803,501	6	....	....	2.72	2.97	1.40
337	Benzo blue 2B	1,789,774	14	2.00	1.37	1.00	.88	.50
363	Benzopurpurine 4B	617,629	11	....	2.46	1.80	1.46	1.10
462	Direct deep black EW	7,736,994	14	....	....	1.04	1.03	.65
463	Erie direct black RX	2,050,741	4	....	....	....	.99	.70
476	Benzamine brown 3GO	623,757	5	....	....	....	1.60	1.10
495	Malachite green	654,237	6	6.28	5.60	3.26	3.32	2.00
515	Methyl violet	600,873	9	3.84	2.78	2.44	2.39	1.80
659	Methylene blue	577,264	12	3.09	2.80	3.03	2.94	1.50
698	Nigrosine (spirit soluble)	919,242	8	1.11	.71	.71	.88	.65
700	Nigrosine (water soluble)	2,743,021	6	.80	.63	.59	.72	.58
720	Sulphur black	16,305,037	12	.60	.37	.29	.25	.20
	Sulphur blue	1,514,811	9	1.63	1.45	1.11	.98	.70
	Sulphur brown	1,269,731	15	....	.48	.47	.35	.30
874	Indigo (synthetic)	18,178,231	3	1.42	.88	.59	.74	.45

obvious by the data contained in Table II. Again it is apparent that there is no monopoly and that prices have been coming down.

TABLE II. DATA ON LARGE TONNAGE INTERMEDIATES

Name	Total Production 1920	No. of Mfrs., 1920	Average Price per Lb. 1917	1918	1919	1920	Aug. 1921
Acetanilide	2,667,252	9	$0.46	$0.53	$0.41	$0.42	$0.33
1-Amino-8-naphthol-3:6 disulphonic acid (H-acid)	5,180,993	12	....	1.69	1.32	1.23	1.15
Aniline oil	39,234,186	14	0.23	0.27	0.24	0.28	0.18
Aniline salt (and sulphate)	2,024,956	5	0.33	0.34	0.38	0.37	0.25
Benzaldehyde	702,543	8	2.72	2.40	0.78	0.63	0.45
Benzidine base	2,071,858	9	1.65	1.01	1.26	1.15	1.00
Benzoate of soda	812,193	8	3.30	2.58	0.88	0.79	0.50
Benzylchloride	1,246,412	5	1.20	0.66	0.23	0.22	0.20
Chlorbenzene (mono)	4,829,142	6	0.20	0.18	0.15	0.10	0.14
Dimethylaniline	5,447,107	7	0.59	0.57	0.55	0.71	0.42
Dinitrobenzene	2,492,178	6	....	....	0.24	0.27	0.21
m-Dinitrobenzene	887,934	5	....	0.28	....	0.29	0.27
Dinitrochlorbenzene	5,947,791	6	....	....	0.21	0.24	0.20
Dinitrotoluene	1,847,191	11	....	....	0.35	0.23	0.25
Naphthalene (refined)	30,230,734	9	0.07	0.08	0.07	0.08	0.07
β-Naphthol (technical)	11,920,714	6	0.67	0.59	0.49	0.47	0.35
1-Naphthol-4-sulphonic acid	561,929	8	....	1.24	1.83	1.41	1.40
2-Naphthol-3:6 disulphonic acid (R salt)	1,250,674	16	....	0.80	0.72	0.66	0.65
2-Naphthol-6:8 disulphonic acid (G salt)	1,446,605	9	....	....	0.82	0.68	0.60
α-Naphthylamine	5,177,547	4	0.44	0.50	0.41	0.34	0.35
1-Naphthylamine-4-sulphonic acid (naphthionic acid)	3,773,191	12	....	0.66	0.62	....	0.60
p-Nitraniline	2,138,492	6	1.13	1.30	1.06	1.17	0.80
p-Nitro-acetanilide	569,728	4	....	0.77	0.69	0.68	0.60
Nitrobenzene	53,244,008	9	0.14	0.15	0.14	0.14	0.12
p-Nitro-chlorbenzene	959,405	5	0.29	0.33	0.21	0.32	0.32
Nitrotoluene	6,100,618	6	....	0.30	0.17	0.13	....
o-Nitrotoluene	2,173,279	4	0.72	0.69	0.23	0.13	0.15
p-Nitrotoluene	2,004,089	7	1.24	1.11	0.56	0.61	0.85
m-Phenylenediamine	658,313	15	1.35	1.10	1.01	1.06	1.00
Salicylic acid (technical)	3,914,163	8	0.66	0.57	0.29	0.29	0.20
Sulphanilic acid	1,796,838	13	0.30	0.29	0.24	0.36	0.25
Toluidine	1,145,361	6	0.76	0.81	0.38	0.37	0.40
o-Toluidine	1,302,097	8	....	0.96	0.50	0.29	0.20
Xylidine and salt	1,054,476	8	0.65	0.54	0.53	0.47	0.40

No, there is no American dye monopoly! Our dyes are being made by many manufacturers, some very large, some very small. They are all selling against one another in open competition. As a matter of fact, every manufacturer who is actually in the business knows full well that the competition is not only in the open, but that it is really much fiercer than in most lines of business. Anyone is at liberty to go out with the salesmen of our dye companies, and we are convinced that a few days' experience will convince him that there is absolutely no monopoly in existence. It there were such a monopoly, it would seem that it must be very inefficiently managed to permit ten, twenty and thirty different independent plants to produce the same product, and also to permit a consistent reduction of prices throughout the list of the products which it manufactures. Increasing the output, decreasing the price and permitting the existence of many plants producing the same article, thereby giving employment to a greater number of persons, are actions not usually ascribed to a monopoly.

If you will take the trouble to look through the capital investments of our eighty-two dye-makers, you will find that they vary from a few thousands to millions of dollars. An examination of the names on the boards of directors shows that there are no interlocking directorates nor other forms of commercial control.

The truths enumerated above are simply *so*, and it is very difficult to believe that those who persist in reiterating that there is an American dye monopoly can be doing so through sheer ignorance of the facts.

The Ideal Paint or Varnish Specification*

BY F. P. INGALLS

Chief Chemist, John W. Masury & Son

IN DISCUSSING the ideal paint or varnish specifications it is of course understood that the ideal or perfect specification cannot actually be written until the sum total of our chemical and physical knowledge shall reach the infinite, yet it is wholly rational to discuss such an ideal, and, by overcoming the obstacles one after another, try to approach continuously nearer to it in practice.

Although the larger part of the paint and varnish sold in this country is purchased ultimately by a large number of relatively small consumers, without any specification other than is implied by the brand or assurance of the manufacturer, there are many buyers who, by virtue of some obligation to purchase at the lowest rates or to avoid favoritism in awarding contracts, must accept the lowest obtainable quotations for satisfactory goods. Under such circumstances it is obviously necessary for the buyer to state in clear and unmistakable terms just what goods will be satisfactory or acceptable and at the same time exclude all other or inferior goods. Such a description is called a specification.

THE PERFECT SPECIFICATION

The most nearly perfect specification is that one which, in the fewest words, best describes the desired paint or varnish so clearly and completely that no inferior product can gain acceptance. The ability to write any such specification not only involves a general knowledge of the possibilities of production from such materials and by such methods as are known to be available, but it also implies the existence of ways and means of determining the probable economic value of the delivered goods before they are put into actual service. In other words, the specification must be based on a knowledge of what can be produced, and how to test the

*A paper presented at the Seventh National Exposition of Chemical Industries, Eighth Coast Artillery Armory, New York, Sept. 12-17, 1921.

delivered goods. This is fairly evident, because in any exchange of goods for money or other value the delivered goods must in general be accepted and paid for long before they shall have demonstrated their value in actual service.

It is scarcely to be expected that any one person can have at his command all the knowledge necessary for the best possible specification, nor that a specification which embodies only the knowledge of one person, however expert, will be universally acceptable. In this country, however, we are fortunate in having at our disposal the collective knowledge and co-operative work of Committee D-1 of the American Society for Testing Materials, a committee numbering about 115 members composed of the leading paint and varnish technical experts, producers and consumers, both having about equal representation. The A.S.T.M. is a permanent organization of about 3,000 engineers and technical experts, and its prime object is to prepare specifications and to define standards for engineering materials of all kinds. Any specification issuing from such a body may be regarded as highly authoritative. A number of other bodies are closely allied with it, especially the U. S. Government Inter-departmental Paint Specification Committee, the Paint Manufacturers Association of the U. S. and the National Varnish Manufacturers Association, all of which have direct representation on Committee D-1. With all this aggregation of talent, operative for a number of years past, it is pertinent to ask, Why are so few complete and satisfactory specifications for paint and varnish available at the present time? The answer to this question brings before us a realization of the really formidable array of obstacles encountered, and the large amount of slow, tedious and painstaking work required to overcome them.

Theoretically paint is a very simple thing. It is merely a solid-liquid two-phase physical system composed of any finely divided, essentially inert powder or pigment, suspended in a liquid vehicle which possesses the property of becoming solid upon extensive exposure to the air. In detail, however, it is no such simple thing, but is on the contrary a highly complicated affair with almost infinite possibilities.

General Division of Paints

The complete list of products of any of our larger manufacturers will show all the way from 300 to 600 or more items, each regularly carried in stock ready for delivery to the purchaser. In addition to these there may be several thousand formulas for special paints or varnishes of one kind or another especially adapted to some unusual or peculiar use. Fortunately these items, although distinct in themselves, may be divided or classified into about fifteen or twenty groups, or lines, of paints and half a dozen classes of varnish, the individuals of each class differing from one another merely in some minor detail, such for instance as color. In a system of classification the difference between the individuals would generally be determined by the pigment present, but the classes would be distinguished by the character and proportion of the vehicle. Paints are therefore usually divided into two grand divisions—namely, paste paints, which require thinning down for use, and liquid, or ready-mixed, paints, which are already thinned down and are practically ready for use; in the first division the proportion of vehicle is as small as is practicable for the grinding process, while in the second division the proportion of vehicle is much larger and is adjusted so as to give the finished paint the required working properties under application. In both divisions the classification rests almost wholly on the quantity of vehicle present and not at all on the character of the pigment.

Although it is desirable that we should have good specifications for paste paints as well as for liquid paints, yet, inasmuch as the paste paints must in general be thinned down before use and in this process may be diverted into any one of several different subdivisions of the liquid paints, according to the character of the thinning liquid, it is only natural that the greater interest should center in the finished paints themselves, and it is these finished paints which not only command the greater interest but also present the greatest obstacles to standardization and specification.

Effect of Chemical Reactivity in Grinding

In theory the pigment of a paint is supposed to be essentially inert chemically, as regards the vehicle, the paint being a plain mechanical mixture of finely powdered pigment with a more or less viscous liquid. In the majority of paints, however, this condition is not immediately realized, because nearly all of the available vehicles contain organic acids in varying degree and kind, and many of the pigments are basic in character, some of them highly so. Under these circumstances a certain amount of chemical reactivity is to be expected, especially under the frictional heat of grinding. From the purely scientific standpoint this does not impair the validity of the theory, for if the new substances formed by the reaction are soluble in the remaining unaffected vehicle, then they become a part of the liquid phase, and if they are insoluble they become a part of the solid phase, so that finally we have a pigment and vehicle which can no longer react with each other. The important point to be considered here is that the resultant paint may, and generally does, have notably different properties from what it would have shown had there been no reaction; furthermore, sometimes these differences may be advantageous and at other times disadvantageous.

In most cases the pigment and vehicle are so chosen that the reactivity shall be relatively very small and fairly constant, but if not so chosen and if the reaction becomes extensive, either at once or during a considerable time, then the paint generally becomes useless, especially on storage. These, however, are not the only complications due to the pigment.

Aside from anything which may be traced directly to chemical reactivity the pigment may have a profound influence in other ways for which, up to the present, there is no tenable and comprehensive theory. Such influence may best be shown by citing illustrative cases.

A good raw linseed oil exposed in a thin film will dry in five or six days at ordinary room temperature. The same oil after the introduction of dryers may be made to dry in seven or eight hours under the same conditions; such an oil is readily obtainable commercially as "boiled" oil and in the trade is a fairly definite product. There are several hundred pigments in common use representing about forty or fifty different types or kinds which differ widely both chemically and physically. When these are ground into paste paints with either raw or boiled oil we notice that while the drying

time of the oil remains unchanged in some cases there are other cases in which it is accelerated and still others in which it is retarded. We shall quote only a few of the extreme cases.

Materials Which Accelerate or Retard Drying

Knowing, as we do, that small quantities of certain metals such as lead, manganese, cobalt, iron and a few others have a pronounced catalytic effect in accelerating the oxidation of oil, we are not particularly surprised to find that such pigments as white leads and umbers accelerate the drying speed, nor is it necessary to postulate anything further than a slight chemical reaction between pigment and vehicle to account for the acceleration. No such explanation, however, will account for the great retardation induced by such pigments as vandyke brown, various carbon blacks and certain coal-tar dye lakes made by precipitating basic dyes with tannin. It is difficult to imagine a pigment more inert chemically than the carbon black made by burning natural gas, and when ground in boiled oil it makes a good practicable paste with about 12 lb. of black to 88 lb. of oil. Good carbon black gives an ash of less than one-tenth of one per cent and contains occluded air sometimes to the extent of several per cent, but whether or not this occluded air is wholly displaced by oil in the ground paste, it is quite certain that any effect which either the air or the trace of mineral matter might have would be accelerative rather than retardant. Whatever might be expected as to the drying speed of such a paste paint, the fact is that twelve to fifteen days are required instead of the seven or eight *hours* required for the oil alone. If the drying time were retarded to only five or six days, it might be explained on the assumption that the metallic dryers are adsorbed by the finely divided carbon and their catalytic effect suppressed, but when the paint requires six or eight days more than raw oil itself, no such assumption is tenable. The different blacks owing their color to carbon do not all show the same degree of retardation, but no sort of chemical analysis reveals any sufficient reason for the observed differences. The most extreme case of retardation coming under the writer's notice was a "tannin-methyl violet" lake ground in raw oil; it did not dry in five months, and even when it could finally be touched was a gummy mess wholly unlike a good paint film. Fortunately lakes of this kind are unimportant, because better ones can be made, and at best they are too fugitive in color for general use, but the case is of considerable academic interest.

Durability and Hiding Power of Paints

Pigments also differ widely in their influence on the durability of paints made from them. This is especially important in exterior paints, or common outside house-paints well known and familiar to almost everybody. Whether this influence is a direct result of the same fundamental principle that affects the drying speed or not is open to question, but there is apparently some close connection, because long experience shows that some of those pigments which exhibit the greatest retardation also have the greatest influence in delaying the decay of the vehicle in service. Other factors probably enter, for it has long been known empirically that if small quantities of colored pigment be added to any given base white paint, the tinted paints so made will outwear the orignal white, and the hiding power is also increased to a much greater extent than would be expected from such a small quantity of color.

A small instrument devised by Dr. Pfund of Johns Hopkins University allows us to measure this hiding power, and in a research bulletin issued from the laboratory of the New Jersey Zinc Co. on Aug. 1 of this year some results obtained by Dr. Pfund are set forth in detail. Among these results he shows that in a certain paint made from zinc oxide the addition of a very small quantity of lampblack raised the hiding power of the paint from 145 for the straight white to 486 for the light pearl gray tint, these figures expressing the hiding power in terms of square feet of black surface completely hidden by one gallon of paint. The proportion of lampblack required for such a tint is not more, and generally less, than one-tenth of one per cent on the zinc present—a quantity apparently out of all proportion to such a result. If any such demonstrable resistance to the passage of the visual rays of light follows the introduction of such small amounts of color, it is highly probable that the actinic rays are also obstructed and their influence in hastening the decay of the vehicle considerably diminished. This seems to be the most reasonable hypothesis, for it is fairly certain that actinism and water are the most potent causes of decay in exterior paints.

Whether paints be regarded as merely decorative or protective, or both, their durability as an economic factor is of paramount importance. No extended argument is necessary to carry conviction on this point for, on the average, it is fair to say that three dollars' worth of labor will be required to apply one dollar's worth of paint. The initial cost of the paint is to be considered, of course, but the real measure of value is the consumer's ultimate cost for continued upkeep, including the labor charges, and ultimate economy is clearly dependent upon the durability of the paint.

Effect Due to Size and Shape of Particles

One other important influence of the pigment must be noted, and that is the effect due to the mere size and shape of the particles. Mixtures of pigments with any paint vehicle do not take on the physical properties characteristic of good paint until the particles present a relatively large specific surface to the liquid vehicle. Roughly speaking, the particle diameter may range from 0.2 micron to 50 microns with a mean average of 5 to 20 microns. When pigments are reduced by any process of mechanical grinding, the particles are far from uniform in size and if the material is subject to cleavage, the diameter in one direction may be much larger than in another, so that in stating average size we do not give a full idea of the physical state. It makes a great deal of difference whether there is a wide range between the maximum and minimum size, or whether the particles are more nearly uniform. The important point to us now is that as the particles become finer the tendency to flocculation increases, and, unless counteracted by the dispersive power of the vehicle, all sorts of changes in the consistency and applicability of the paint may ensue. However interesting the further discussion of this phase of the subject might be, we are concerned here only with the relation of such effects to the preparation of specifications, and enough has been said to show that they alone would render difficult the full description of a paint by merely specifying the ingredients and their proportions.

Whatever the difficulties arising from the pigment,

those arising from the vehicle are quite as great. There is no practical vehicle composed of a single unitary substance of fixed properties, and rarely if ever is the vehicle of a finished paint composed wholly of any one of the drying oils in its original state; almost invariably metallic dryers must be added, and while our knowledge of some of them is satisfactory, we know much less about those which have been prepared by the various cooking processes in common practice. Even linseed oil itself comes to the paint manufacturer in no fewer than five types—viz., raw, refined, boiled, bodied and blown—all in daily use, and when we consider the cooked and uncooked mixtures of the various drying oils with other substances whose chemistry is even less definitely known, we are forced to realize the essential hopelessness of attempting to describe them in terms of composition.

If then such obstacles to full specification by composition are interposed by both pigment and vehicle, what are we to do? The answer to this question is easy, but the preparation of a good specification founded on this answer is more difficult. If we consider paint from the consumer's standpoint the composition is of no great moment except in so far as the presence or absence of some particular ingredient positively adds to, or detracts from, the economic value of the paint. The consumer buys paint for what it will *do* and if he can rely upon a definite performance in service his further interest is perfunctory. We may write a good specification therefore by stating what the paint shall do, knowing of course that such a paint can be made, and the only real obstacle to this procedure is that we have no trustworthy test that will indicate with reasonable certainty the probable durability of the paint in service.

Durability Tests

Experience shows that the value of paint rests chiefly on five main properties—namely, color, degree of gloss, hiding power, working properties and durability, all physical attributes. All these, except durability, are susceptible of quantitative measurement, and if we could measure durability, we could determine the economic value of such paints without knowing anything about their composition.

When Committee D-1 first began its systematic study of paints it quite naturally attacked the problem from the chemical side on the reasonable assumption that if the composition were fixed the physical properties must also be fixed. Some of the reasons why such a method could be only partly successful have been given above in considerable detail. The committee soon realized that the subject was complicated, and in order to simplify matters confined its attention for some years chiefly to one type of white paints. On the Arlington test fence alone about 240 white paints were tested out in which the differences were due chiefly to changes in the proportions of the more common white pigments while the vehicle was maintained as nearly constant as possible. Supplementary tests of a similar kind were carried out, literally in thousands, by individual interests, but in spite of every care and an enormous amount of work, the knowledge derived has not been considered enough to serve for a satisfactory specification. The more recent efforts therefore have been directed more toward a study of the important physical properties, and the present tendency is to demand certain physical properties in a quantitative degree, putting up to the manufacturer the problem of how to get them in.

Specifying varnishes by composition has met with the same obstacles that pertain to paint. Until very recent times the attack has been from the chemical side despite the fact that our chemical knowledge of even the raw materials involved is incomplete, meager, and sometimes even no more than speculative. Varnish is simpler than paint in that there are no complications due to pigment, but when two problems are both beyond our capacity to solve, it makes little difference which is the more complex.

The Kauri Reduction Test for Durability

During the war large quantities of varnish of maximum durability were required and there was great need for some test which would give some indication of the durability of the many brands offered. Under the stimulus of this pressure a method of test was developed from an idea that has been regarded as axiomatic in the varnish industry for generations. No gum-and-oil varnish yet made has anything like the durability of a first-class linseed oil paint in which the vehicle is practically all linseed oil with only the minimum proportion of dryers, and as the proportion of gum in varnish increases, the elasticity and durability are diminished. It has always been held that finishing varnishes which are required to withstand exterior exposure should always be "long in oil" and that elasticity and durability were accompanying features more or less in direct proportion. After thorough drying, short-oil varnishes crack readily when sharply bent, and therefore if we add more gum to a long-oil varnish until it cracks when bent we have a measure of the "length" of oil, and consequently the probable durability. This test is the so-called "Kauri Reduction Test" and for the detailed method of carrying it out we must refer you to the latest Inter-departmental specification for spar varnish. Whatever the further development of this test may show, it is founded on many years of solid experience, and while its results may not run exactly parallel to the service tests in all cases, yet as a test it is less liable to error than the service tests themselves unless the latter are carried out with most unusual care.

For some time yet it may still be desirable to include in varnish specifications the composition desired so far as that composition can be determined by analysis with reasonable accuracy, but by specifying what the varnish shall *do* and expressing it in terms which our present knowledge can measure quantitatively we are taking a long step ahead.

Much Progress in Recent Years and Future Full of Optimistic Expectations

During the past five or six years in which the attack has been active from the physical side much more progress has been made than in any previous similar period. Work is now under way which we hope will result in an accelerated test for durability in paints, and if this hope is realized the future is rosy with the optimistic expection that, while we may not indeed reach the ideal, yet, for the first time in the history of the industry, we shall be able to standardize with reasonable accuracy the more important types of both paint and varnish, and write specifications which will be rational, sound and useful.

Brooklyn, N. Y.

Sidelights on the Chemical Exposition

General Impressions of an Interested Spectator and a Brief Account of Some of the New Products, Apparatus and Materials Exhibited at the Seventh National Exposition of the Chemical Industries, New York, Sept. 12 to 17

THERE were many new things to be seen at the chemical exposition this year and many old things were dolled up in new clothes and made to look attractive. It would have required weeks to inspect everything and to talk with all who were in charge of the many interesting exhibits. The writer of these brief notes is frank to admit that he didn't see everything. In fact there were a lot of important developments which he missed entirely and he probably wasted a good share of his time gossiping about inconsequential matters. However, he did observe many unusual things, and these notes were jotted down with the idea of conveying some of his impressions to those who were unfortunate enough to have missed the chemical show or were too occupied to make a detailed study of the novel products, apparatus and equipment. No effort has been made to arrange these items according to importance, novelty or interest and they are presented with an apology for their many errors of commission and omission.

THE DYE MAKERS were very much in evidence. The most elaborate architectural effort was doubtless the exhibit of the National Aniline & Chemical Co., although the booths of the Calco company, Klipstein and Sherwin-Williams were quite notable. The National's exhibit was one of a central group of the related corporations—Barrett Co., Solvay Process Co., and General Chemical Co.—and represented an old Egyptian street. For background on either side were the blank walls of the dwellings, interrupted here and there by doorways. At the street corners were four high ornamental pillars. All these structures and the partitions outlining their exhibits were painted in very harmonious blues, reds and yellows—rather soft and subdued as one would expect of colors generations old. The dooryards were shaded by more brilliant yellow awnings. The rumor that Sherwin-Williams was gradually giving up its coal-tar departments was completely refuted by a prominent array of new products, which included dyes for lake and ink manufacture and a new rubber accelerator known as formaniline. Attractive samples of fur, cloth, carpet and paper which had been dyed with these products gave an idea of the scope of this company's activities.

AN AIR OF DIGNITY and seriousness of purpose characterized the display of the Calco Chemical Co. The many new pharmaceuticals being developed for household and professional uses were given positions of prominence. Among these were calusol, a household antiseptic, and salicaine, a new local anæsthetic to take the place of cocaine.

KLIPSTEIN'S E HIBIT was housed in a dazzling white pergola, with royal blue hangings for background—a colorful exhibit, much simpler in design than the Egyptian street, but nevertheless extremely impressive. But with these few notable exceptions, the dyemakers' exhibits seemed less attractive than last year; perhaps that was because we were continuously meeting a party of dusky-skinned strangers, probably native of some country in southern Asia. One woman was draped in a magnificant shawl, of Oriental red, with a border vaguely suggesting the Paisleys dear to our grandmothers. Were the writer a dyemaker, he would try to make that red.

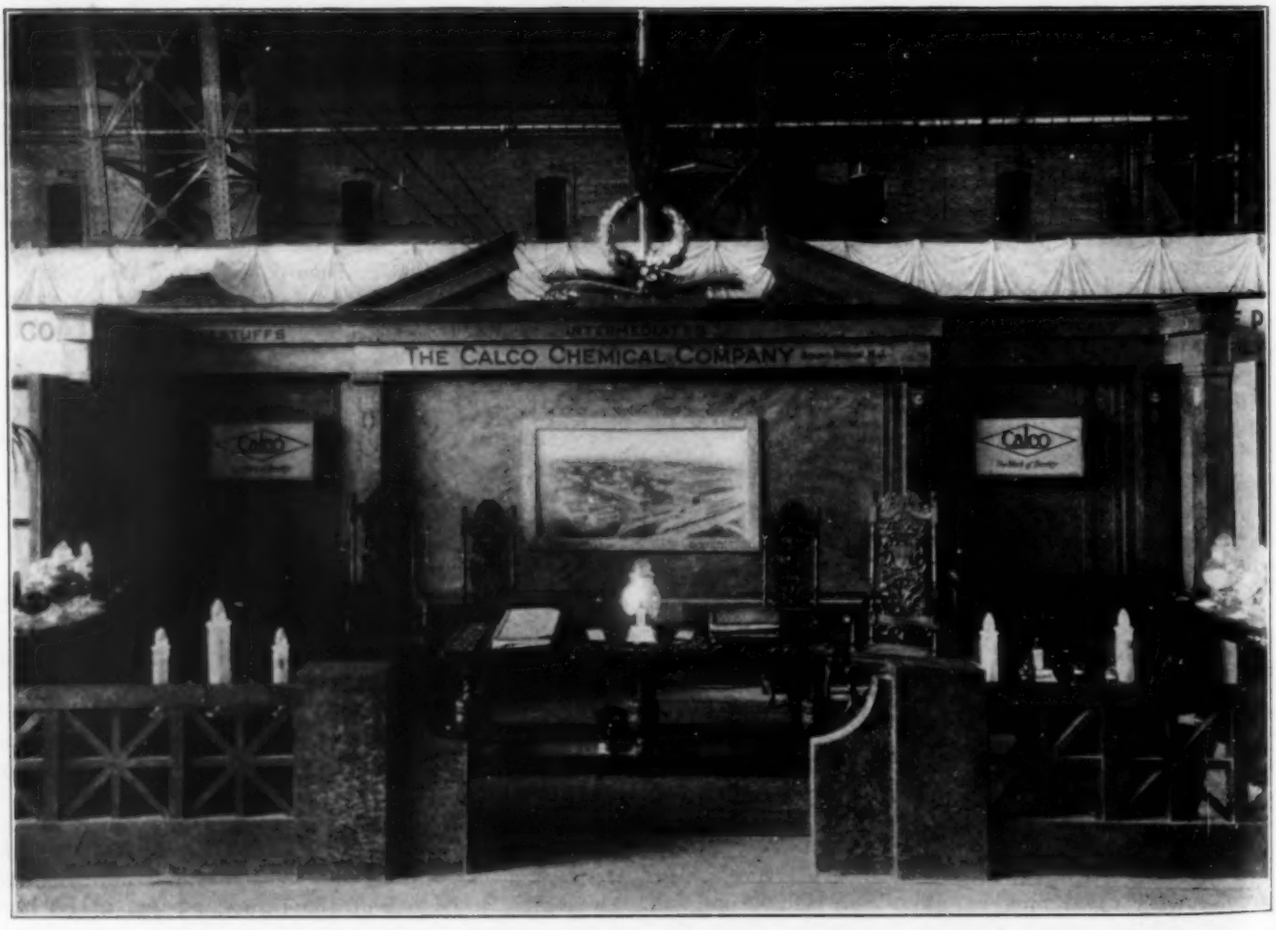
TWO OTHER BRIGHT SPOTS ON THE HORIZON were the colorful exhibits of the Newport Chemical Works and the Chemical Co. of America. The former now claims the distinction of having a very complete line of the famous vat colors of the indanthrene series. A number of new dyes have recently been added to this important series and as a result the number of products "not obtainable in the United States on reasonable terms as to price, quality and delivery" has been lessened.

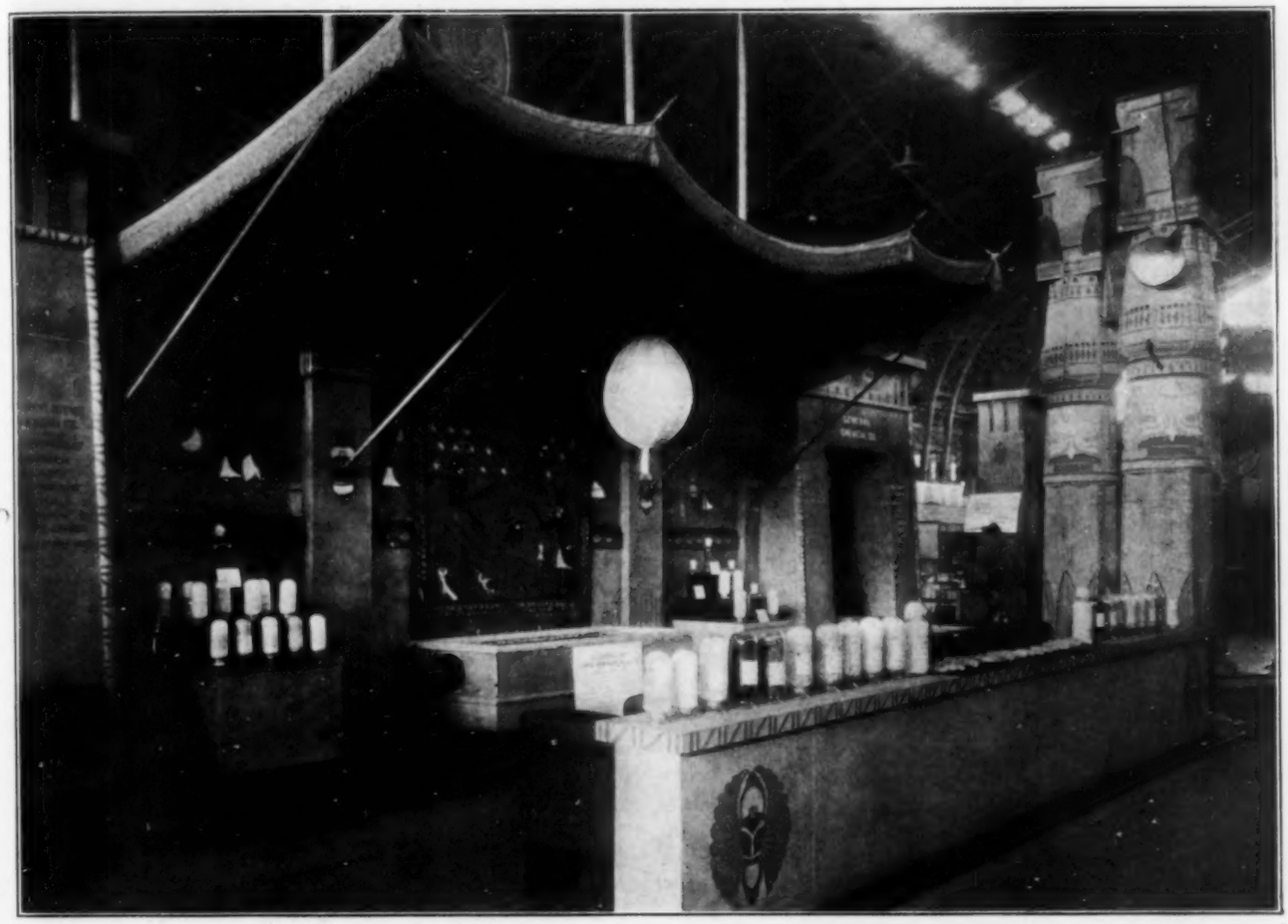
A FEW BOOTHS, here and there, were vacant. Others seemed to be packing up, ready to go—but when you came closer, it proved that they were exhibits of trucks or other package-handling equipment. And speaking of packages, were you not struck with the number of booths which exhibited barrels, boxes, paper cartons and such like containers?

REVERTING TO VACANT BOOTHS, some were vacant and some were almost vacant. They suggested that the stingy hand of economy had intervened between the time when the space had been paid for and the construction of the exhibit. But still that explanation does not altogether fit the du Pont company. Last year everyone was greatly impressed by its magnificent purple hangings, reaching clear from ceiling to floor. And where was the collection of notable machinery which has featured the Buffalo Foundry & Machine Co.'s space in every exhibition since the first, and has almost become an institution?

THERE IS AT LEAST ONE COMPANY which keeps its chemists at work when dull times come and sales fall off. As a result it has developed a new product which promises to revolutionize gas engine manufacture. We refer to Dowmetal and its use for the piston heads of internal-combustion motors. As a conductor of heat it is three times as effective as cast iron and because of its lighter weight, engines can be speeded up to give more power with less strain. They don't generally boast of the fact, but the winning cars in the Indianapolis races were equipped with Dowmetal pistons. While the writer was discussing these things with Mr. Dow a man walked into the booth and, approaching the learned president of the Dow company, asked him if there was anybody there who understood chemistry.

THE SHERWIN-WILLIAMS CO.
NORTHINGTON PUMP AND MACHINERY CORPORA
NEW YORK
SANDOZ


THE CALCO CHEMICAL COMPANY
Calco
Calco



U.S.INDUSTRIAL ALCOHOL CO. — U.S.INDUSTRIAL CHEMICAL CO.
EXECUTIVE OFFICES 27 WILLIAM STREET, NEW YORK

With a whimsical smile Mr. Dow pointed to one of his associates near by who, he thought, might be able to talk with him. To ask this former professor of chemistry and toxicology if anybody around there knew any chemistry seemed funny, but the question would not down, whether it would be funny or sad to ask the presidents of many of our chemical corporations whether they knew any chemistry or not.

ONE OF THE REALLY NEW THINGS that attracted genuine interest was a new gyroballistic crusher that simply eats up the rock. The Stimpson Equipment Co. introduced several years ago the Mitchell screen, whose vibrating motion is caused by the very rapid vibration of a slightly balanced electric motor. The same kind of prime mover has now been applied to the top end of a crusher shaft with astonishing results. An entirely new principle is applied to crushing, wherein a force formerly considered destructive (vibration) is used constructively to produce an action of a cracking rather than crushing nature. The power requirement of the new machine is a paradox in that it is less while the apparatus is crushing than when it is operating without a load.

A MORE ELEGANT-LOOKING APPLIANCE is the new gas governor, designed by the Koppers Co., and primarily intended to regulate the pressure in the byproduct coke oven, thus preventing wastage of rich distillate from the coking coal through the brickwork, or the in-breathing of waste gas from the flues. Each battery of ovens has one of these governors operating a butterfly valve in the suction main leading to the recovery apparatus. As the pressure in the retorts goes up, from any cause, a float is raised which is connected by suitable linkwork to a pilot valve. The latter controls the flow of a body of circulating oil, allowing some of it to enter certain cylinders, whose rising pistons open the butterfly valve sufficiently to bring the gas pressure back where it belongs.

TO CATCH THE FEMININE EYE—and it did effectively—not a few exhibitors showed how their products entered into household utensils and furnishings. Many observers probably never before realized that applied chemistry is vitally necessary for their comforts. Lacquered, enameled and plated ware of all kinds were attractively exhibited; glassware and porcelains, and cooking utensils of aluminum, copper and nickel competed to catch the eye.

IF THE PROMINENT METALLURGICAL COMPANIES would collectively exhibit, it would make a metallurgical exhibition of considerable proportions. New Jersey Zinc Co. had a beautiful booth in blue and white, a background most effective for the silvery brightness of most of its articles on show. Other observers might offer first prize to the Nichols Copper Co. Its booth appeared to be the facade of a Greek temple, severe in the extreme. Directly in front was a large pedestaled fruit bowl made of sparkling crystals of blue vitriol. It was heaped with luscious fruit; a veritable altar to Demeter.

ANACONDA COPPER MINING CO. is to be especially complimented for a well-designed and harmonious exhibit. Not only was there an adequate showing of the several metals the company produces in bulk and various byproducts, but there were also many specimens of chemical apparatus made of copper or copper alloys. Several manufacturers of copper utensils co-operated in this effort, contributing excellent panels or cases. For instance Duparquet, Huot and Moneuse loaned a very interesting collection of copper kettles and jelly molds, while Manning-Bowman's case of polished trays and percolators was particularly striking.

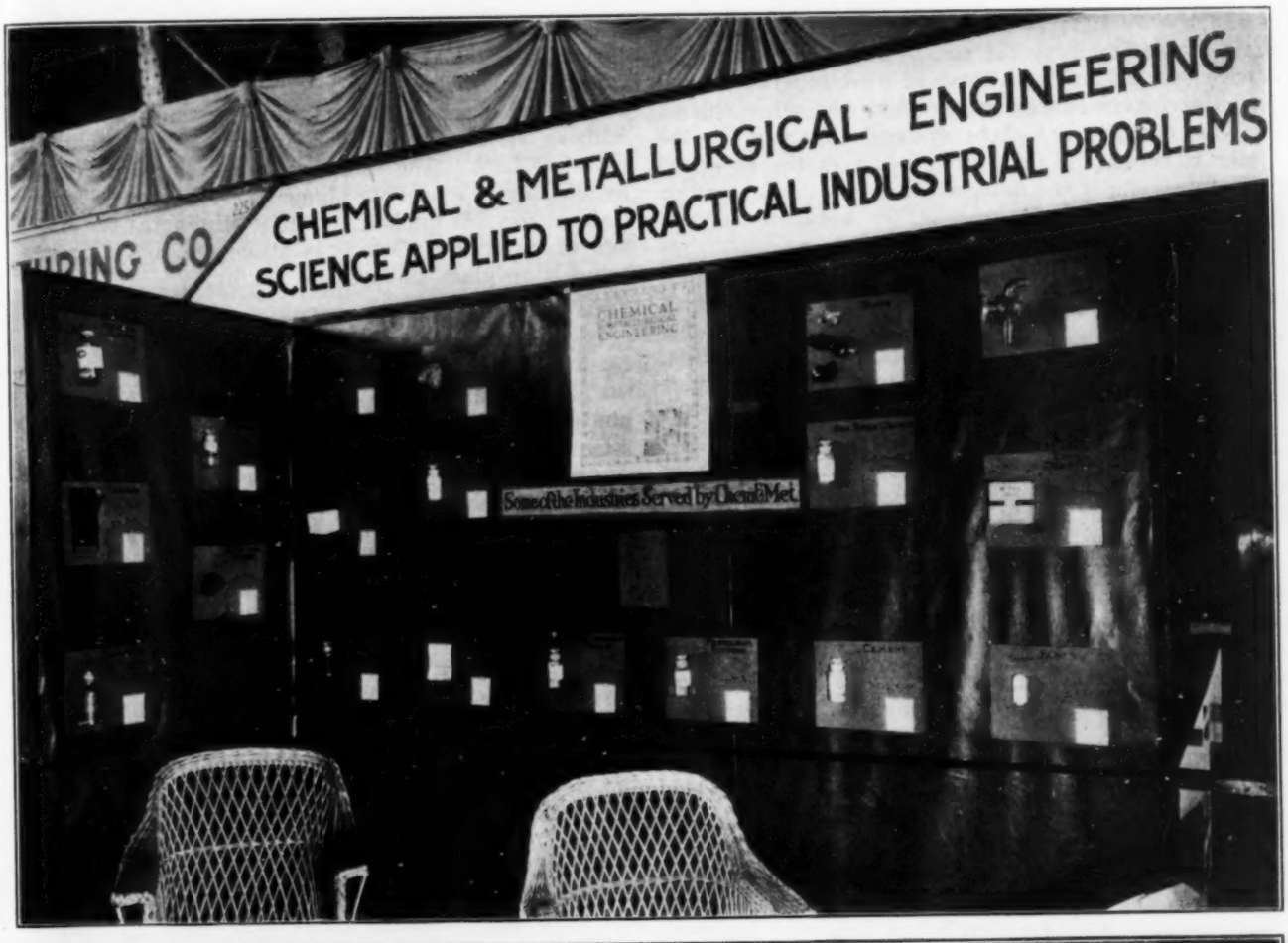
A NEW FORM OF DUCTILE NICKEL about which we have published several papers was exhibited by the British-America Nickel Corporation. A mammoth cathode, 20 ft. long, 5 ft. wide and ½ in. thick and weighing 400 lb. was of especial interest, as was the company's statement that it is equipped to produce fifty such cathodes at one time. The new product was the result of five years' work in the laboratory of Mr. Madsen, for whom the metal has been named.

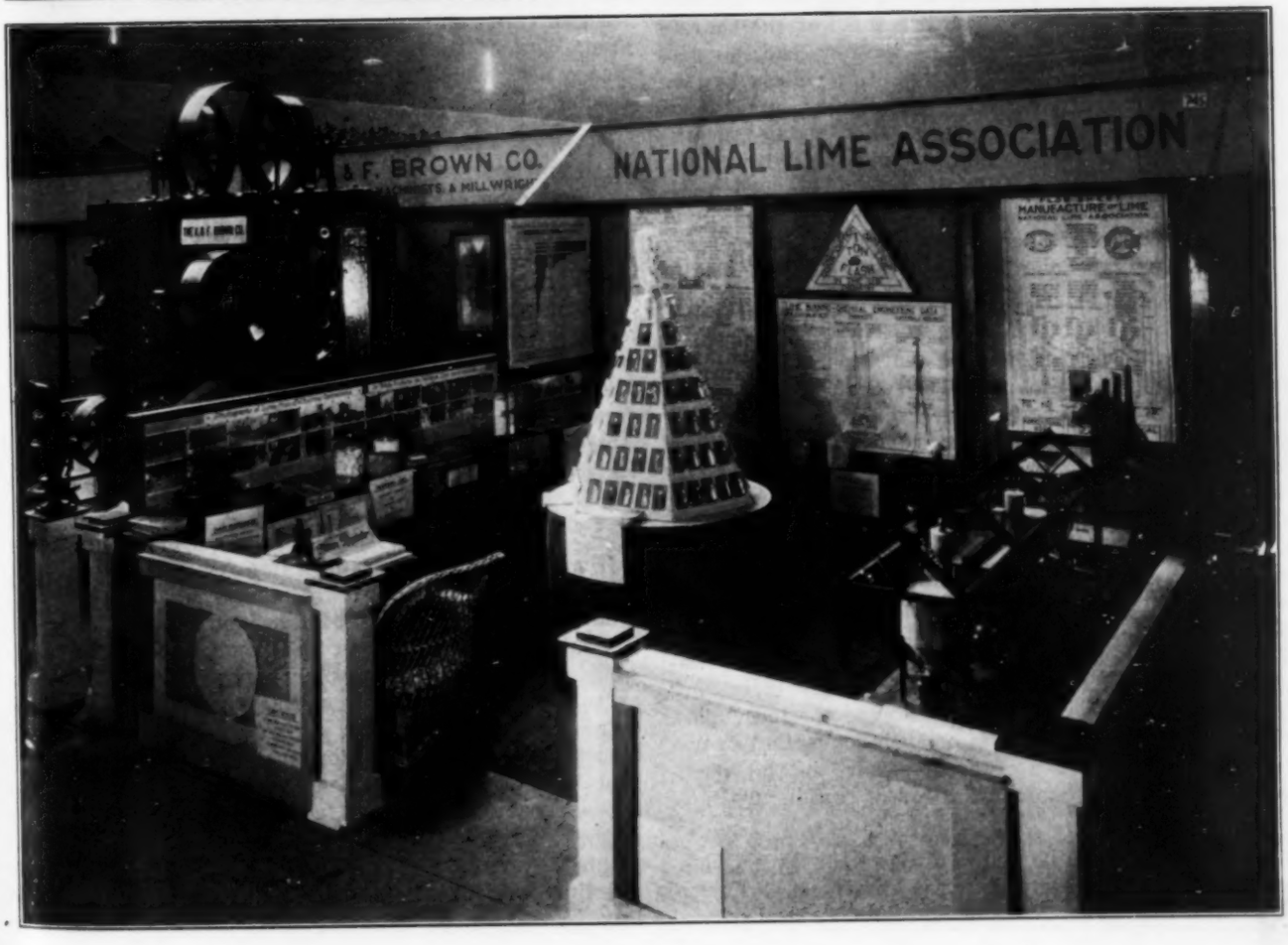
AS WAS SAID BEFORE, the du Pont company did not bring any of its many products to the exposition. The man at the desk labeled "Dyestuff Department," however, informed the writer that the company is now ready to announce the arrival of the Naphthol series of fast reds, scarlets, oranges, blues and pinks. These are the famous Naphthol AS colors introduced by the Griesheim works shortly before the war and their production in this country fills one of the last remaining gaps in fast colors for cotton.

"CANADIAN PACIFIC RAILWAY CO.—Exhibiting a colored map showing the industrial resources of Canada." This bare statement contained in the program certainly raised no great expectations. But the map was no ordinary colored map. It was a huge white thing; perhaps 20 ft. long and half as high, with a few sketchy outlines in black. In front was a switchboard. If you wished to see the route of one of the great railroad systems, merely press an appropriate button, and immediately flashed up a continuous line of miniature light bulbs; the names of the principal cities en route were also illuminated. Or if you wanted to know where Canada's precious metals were mined, push another one of the score of buttons and tiny red lights glittered here and there—Yukon, Rossland, Porcupine and dozens of others sprang forth. A regular Aladdin's map!

THAT PROMISING YOUNG OFFSHOOT of the Davison company, the Silica Gel Corporation, exhibited apparatus showing some important industrial uses for silica gel. For instance, in the Gayley process the gel is used to reduce the moisture in the blast for iron furnaces without refrigeration. The moisture content is brought down to ½ grain per cu.ft. Adsorption from the gas phase is the basis for important uses of silica gel in refrigeration and in the manufacture of sulphuric acid by the lead chamber process. Removal of sulphur compounds from Mexican petroleum and the refining of various petroleum distillates by means of this gel depend upon its properties of adsorption from the liquid phase. Silica gel will adsorb 18 to 20 per cent of its weight of these offensive smelling compounds, and furthermore the gel can easily be repurified.

A NEW ROLLER PUMP which is as simple as rollin' off a log is the description given to the latest novelty of the Dorr Co. The pump is for any fluid or mud that can be passed through rubber tubing. The lower end


CHEMICAL & METALLURGICAL ENGINEERING
SCIENCE APPLIED TO PRACTICAL INDUSTRIAL PROBLEMS
Some of the Industries Served by Chem. & Met.


NATIONAL LIME ASSOCIATION

of the rubber tube is placed into the material to be pumped, and adjoining the pipe is a hard plane surface. A wheel (or spider) with three or more rollers attached at the periphery is also immersed on the other side of the pipe opposite the plane surface. Then, when the spider revolves, the first roller squeezes the pipe and pushes up some of the fluid, while before the first roller has been withdrawn the second has begun to squeeze upward, and so with the third, until a continuous stream is on its way—a sort of peristaltic motion applied to pumping.

NOW THAT p_H HAS COME SO VERY MUCH IN VOGUE, considerable attention has been attracted by the Elliot ionometer, which appears to be a rough and ready instrument adapted for rapid work and factory control. The Will Corporation declared that it is of especial service where dark solutions prevent the use of ordinary indicators.

A NEW SODA FOUNTAIN DRINK called "Cheerio" was dispensed to all comers at the booth of Heyden Chemical Co. Whether the great "heart" of the American public will take to it as it has taken to "Coca-Cola" or whether it will adopt the new synthetic grape juice of the Florasynth Laboratories, remains to be seen.

AN IMPORTANT INNOVATION in chemical engineering construction may follow the development of 3-in. Pyrex glass pipe-lines with T and L connections to be used as a substitute for brass pipes. The installation in tanneries for handling tanning liquors suggests important uses in other chemical industries.

SAMPLES OF A METAL which has some of the characteristics of bronze, but contains neither lead nor tin, were distributed in the form of little chisels by the American Metal Products Co. The alloy is made of copper, steel, aluminum and one other metal in varying proportions to serve different purposes, with copper preponderating. We suggest that this be called hardened copper, so that when gifted inventors come around with the secret of the lost art of hardening copper for sale for a million dollars, they may be told that it is done already.

ONE OF THE REASONS FOR THE CROWD which constantly surrounded the exhibits of the Bureau of Standards was the fact that many features were being carefully explained by the men who were responsible for the inventions and discoveries. For example, C. O. Fairchild showed the results of his process for the fusion of optical glass cells and similar articles which cannot be molded because of interference with optical properties. Formerly these were cemented and the cement was often a source of trouble. A small sample of the platinum developed by Dr. Edward Wichers was shown. The fact that it is spectroscopically free from any impurities suggests the possibility of greatly increasing the utility of rare-earth and resistance thermocouples. Priest's spectrophotometer is of such convenient operation that it may prove of great service in the much-needed work on the standardization of coal-tar dyes.

AFTER A VISIT to the booth of the Lake Erie Chemical Works of the General Electric Co., it is not difficult to predict that hydrofluoric acid will soon be displaced in the production of frosted effects on glass. With Permel, a colloidal suspension of a mixture of inorganic compounds, similar results can be obtained more easily and at less expense. The mixture is simply sprayed on with an air brush and then fixed by development in a chemical bath. The finish may be colored if desired by the use of inorganic pigments. Another advantage claimed for this method is that it eliminates the breakage which occurs when it is attempted to fix frosting enamels on glass surfaces by baking.

IT MUST BE ALMOST LIKE SPLITTING HAIRS to manufacture an 840-mesh wire cloth, and it is no wonder that A. A. Campbell of the Newark Wire Cloth Co. felt himself called upon to design a special microscope for accurately measuring such fine mesh. By the use of a special micrometer stage this unique instrument measures accurately to one one-hundred-thousandth of an inch and it is claimed that with a vernier scale the accuracy was extended to one millionth of an inch. Although Mr. Campbell's device was built to serve a special purpose, it would appear that it might find important application in many other industries.

DOWN SOUTH THE LUMBER AND NAVAL STORES INDUSTRIES have for years been destroying yellow pine trees with such reckless abandon that less than one-third of the tree ever reaches the market in the form of lumber, lath or shingles. The stumps are left in the ground, for the enormous cost of removing them has in the past made it impracticable to reclaim the land. Chemical engineering has now appeared on the scene and pulp and wrapping paper and many byproducts, such as turpentine, pine oil and rosin, are being recovered. One of the pioneers in this field is Joseph Wallace & Co., which company demonstrated some of its accomplishments at the exposition.

A NUMBER OF THE SCIENTIFIC SOCIETIES AND TRADE ASSOCIATIONS took advantage of the educational opportunities offered by the exposition and used their booths to disseminate information to the general public regarding the scope of their activities and the possibilities for progress in their particular fields. These booths also proved convenient meeting places for members and were the scenes of many interesting reunions. Prominent among the society booths were those of the American Chemical Society, American Ceramic Society, American Electrochemical Society, Society of the Chemical Industry and the New Jersey Chemical Society.

IS THERE A CHEMIST who could spend fifteen minutes in the booth of the National Lime Association and not come away with an overwhelming realization of his ignorance on the subject of lime and its uses? On a pyramid in the center of the booth were arranged samples of 120 products which require the use of lime at some stage in their manufacture. A large chart detailed the uses of lime according to industry and according to function. Lime manufacture was visualized by a clever mechanical model of a lime plant, a flow sheet of the process, a chart giving the chemical engineering data involved, and photographs of typical plants. A feature of popular interest was a flashing red light which indicated the rate of consumption of lime in the United States—one ton every 2½ seconds.

Meeting of the Fertilizer Division, American Chemical Society

THE fall meeting in New York of the Division of Fertilizer Chemistry was held Wednesday and Thursday, Sept. 7 and 8, 1921, under the chairmanship of F. B. Carpenter. H. C. Moore was secretary.

The only discussion of phosphate supplies on the program was a report by Waggaman on the briquetting and use of Florida and Tennessee phosphate rock for manufacture of phosphoric acid. Full details have been given by him in CHEMICAL & METALLURGICAL ENGINEERING (Dec. 1, 1920, p. 1057, and Sept. 14, 1921, p. 517).

CYANAMIDE IN SOME FERTILIZER MIXERS

Cyanamide as a fertilizer material was defended by W. S. Landis, who presented an elaborate reply to the article by Harger, which was given at the Chicago meeting of the division last fall. Both ton-lot and laboratory-scale tests were reported to show that in the quantities recommended the cyanamide does not form dicyanodiamide, a plant poison, in objectionable amounts "when it has been properly incorporated in the mixture." By analysis of the mixtures thus prepared it was attempted to identify the condition of all the added nitrogen, but from 15 to 50 per cent could not be found by the methods used. It was believed that only negligible percentages remained as dicyandiamide, the major part being as amino acids, guano-urea and urea.

J. E. Breckenridge reported also on cyanamide fertilizer experiments with the output of the American Agricultural Chemical Co., in which the Bureau of Soils co-operated. Tests of mixtures containing 40 lb. per ton of cyanamide show these to be safe from toxic plant materials.

Discussion by Harger and Schreiner of the Bureau of Plant Industry made clear their desire not to criticise the use of small amounts of cyanamide as is now trade practice, but their objection to the conclusions drawn by Landis according to the analytical methods which he used. It was also stated that Harger's work was the first presentation of the facts regarding the important influence of acid phosphate on the reaction by which the polymerization of cyanamide takes place.

WOOL SCOURING WASTES FOR FERTILIZER PURPOSES

Wool scouring wastes for fertilizer use offer promise if the U. S. Department of Agriculture results presented by F. P. Veitch can be realized in practice through co-operation of wool and fertilizer interests. The 300,000 tons of unscoured wool used annually in the United States averages 4 per cent K_2O, 0.5 per cent N and 15 per cent grease, with the first two named in useful water-soluble forms. The "concentrates" mix well with other materials and appear otherwise good.

GREENSAND AS A SOURCE OF FERTILIZER POTASH

Potash from greensand as a commercial proposition was discussed at length by R. N. Shreve, who presented figures as to the plant to use this method on 1,000 tons per day of greensand. This plant will make KNO_3 and caustic soda by treating the sand with lime at 470 deg. F. in the presence of $NaNO_3$. The byproduct caustic made will be 40 tons NaOH per 100 tons KNO_3, thus justifying use of $NaNO_3$ instead of NaCl in the reaction, for most if not all of the expected output of 20,000 tons K_2O equivalent per year. The solid residue from the process will be used for brick manufacture and special potash salts.

OTHER PAPERS PRESENTED

The use of triangular co-ordinates was cleverly described by Oswald Schreiner in explaining methods and interpretation of results in field use of three component fertilizers. The failure of many experiments to indicate the action of commonly used fertilizers—e.g., high potash for potatoes—was shown.

L. S. Bushnell emphasized a similar problem and use of similar methods in discussing the limiting constituents in fertilizer effects.

The soil and plant problems were covered also by J. J. Skinner's and H. A. Noyes' reports.

Analytical methods for nitrogen determination were on the program in papers by Charles S. Cathcart, J. E. Breckenridge, R. N. Brackett, H. C. Moore. Other analytical problems were covered by R. McG. Shuey, C. G. Atwater, Paul Rudnick and C. S. Robinson.

Meeting of the Rubber Division, American Chemical Society

THE fall meeting in New York of the Rubber Division, American Chemical Society, was held Wednesday and Thursday, Sept. 7 and 8, 1921.

In the beginning the Rubber Division was more or less of an experiment. Even its strongest supporters were dubious as to the outcome. Two years have now passed since its inception. Five meetings with steadily increasing interest have been held. There are over two hundred members, and finances are in excellent condition. In the beginning it was difficult to get the members to express their opinions, but at the meeting this year it was difficult to keep to schedule, so many had ideas which they wished to present. Without the least exaggeration it can be said that America's rubber technologists got together on a common basis for a full and free discussion of fundamental problems.

It was this spirit that prompted the division to pass unanimously a resolution calling the attention of the Rubber Association of America to the need of co-operative research for further investigation of the fundamentals of the industry.

With but one important exception, every American company interested in rubber has contributed something during these two years. One company, however, which is exceedingly well equipped, has so far declined to take anything but a selfish aspect of the situation. Thus far its organization has contributed nothing, and is apparently proud of it.

Election of officers took place at the close of the Thursday morning session. In recognition of his excellent contributions on the subject of acceleration, the division chose C. W. Bedford, of the Goodyear Research Laboratories, for chairman, to succeed W. W. Evans, of Goodrich, retiring. Arnold H. Smith, of the Thermoid Rubber Co., of Trenton, was re-elected secretary.

MECHANISM OF THE ACTION OF ZINC COMPOUNDS

C. W. Bedford and L. B. Sebrell presented the fourth part of their study on the Reactions of Accelerators During Vulcanization. This paper was by far the most important contribution to the chemistry of rubber presented in the two years the Rubber Division has been in existence. An abstract cannot do it justice.

Zinc oxide enters into chemical combination with the accelerators it activates and produces zinc salts which are much more powerful.

Zinc higher sulphides were described, which produce vulcanization in a manner similar to antimony sulphide.

The authors found that if H_2S and SO_2 are passed into cooled benzene and then one of the gases is run in for a time after the other is shut off, a form of sulphur, thiozone, is produced, which when stirred into a rubber cement brings about vulcanization with setting of the cement in about 40 minutes at room temperature. This is evidently the key to vulcanization by the Dubosc-Peachey process.

Mineral Rubber

C. Olin North presented a paper on mineral rubber. This paper contained the most thorough inquiry into the effect of a compounding ingredient on rubber that has appeared to date. Mineral rubber is prepared by blending gilsonite and natural or blown asphaltic still residue. Various tests, such as stress-strain relations, hysteresis, permanent set, abrasion and elongation under constant load, were made with stocks containing an increasing volume ratio of mineral rubber. From 7 to 10 volumes of mineral rubber per 100 volumes of rubber were found most advantageous.

The Tetra-hydrophenyl Derivative of Rubber and Its Tetra-methyl Ether

Harry L. Fisher and Harold Gray presented a paper on tetra-hydophenyl derivative of rubber and its tetramethyl ether. Some old work of Weber's was repeated and a previous error corrected. When rubber tetrabromide is treated with phenol, hydrobromic acid is split off and a product having the following formula is produced:

$$[C_{10}H_{16}(C_6H_4OH)_4]_x$$

This is soluble in caustic soda solution with the formation of the sodium salt. When this solution is treated with dimethyl sulphate the tetramethyl ether

$$[C_{10}H_{16}(C_6H_4OCH_3)_4]_x$$

is produced. These compounds may serve to determine the molecular weight of rubber.

Corrected Strain Curves for Rubber

J. W. Shields presented a paper on corrected strain curves for rubber. The author corrects the stress-strain curve for decrease in cross-section area. In other words, he draws the true curve based on the actual area of each increase of load and a curve without the familiar S hook is obtained. It is similar to that obtained for other materials. Hooke's law holds for such curves which have the equation:

$$S = CE + \left(\frac{e}{B}\right) \times \frac{1}{K}$$

S = stress corrected for decrease in cross-section area.

e = elongation in per cent divided by 100.

E = Young's modulus.

C, B and K are constants.

The equation is said to apply to a wide variety of curves.

The Determination of Particle Size of Pigments

W. W. Vogt presented a paper on the determination of the particle size of pigments. A rapid method for testing the average size of particle of various pigments was described. The author prepares a suspension of pigment in liquid. Castor oil and carbon tetrachloride or glycerine and water may be used, depending on the nature of the pigment. The suspension is placed in a Nessler tube and the height of column adjusted so that the wires of a tungsten lamp placed underneath cannot be seen. The volume of filler necessary to obscure the area of the bottom of the Nessler is calculated to sq.cm. per c.c. of material and is known as the obscuring power. The method is said to be excellent in checking relative size of the same pigment.

Rubber Research and Rubber Testing

O. de Vries presented a paper on the preparation and testing of crude rubber.

Dr. de Vries is the director of the Dutch Experiment Station of Java. His visit to this country is for the purpose of ascertaining the direction research on rubber should take. He pointed out that much of their work on regulating the uniformity of rubber in cure and other properties is apparently without value to the American consumer. He wants to produce a better rubber and has compiled a set of questions which will be mailed the members of the division by the secretary within a short time.

Appearance of crude rubber is no guarantee of its inner properties, such as its rate of cure, tensile, etc. Resting trees slows down the rate of cure. Smoked sheets mill better than pale crêpe.

In the discussion, W. B. Weigand presented a method for arriving at relative plasticity. A square sheet is cut off the mill, and the crawl or contraction noted.

Other Papers Presented

The Microscopy of Rubber Fillers: By Irene C. Diner.—This paper is preliminary to work on analysis of rubber compounds by use of petrographic methods. Optical constants and the effects of single and double polarized light for several of the more common fillers were described.

The Use of the Microscope and Photomicrographs in the Study of Inorganic Materials Used in Rubber: By Benton Dales and W. W. Evans.—Various fillers were dispersed in a 5 per cent rubber cement. Slides were prepared by floating them on the cement, after which the films were vulcanized by sulphur chloride. By loosening one end from the glass the thin film could be placed under any desired strain and its effects noted.

Recent Developments in the Art of Rubber Microsectioning: By Henry Green.—Previous methods described by the author required the use of liquid air and liquid CO_2 for freezing the sections before using the microtome. Liquid air is not accessible to all. Mr. Green has worked out a method whereby the sample is badly overvulcanized in sulphur chloride, after which it can be sliced as easily as if it were frozen.

Rapid and Low-Temperature Vulcanization: By G. S. Whitby and A. H. Smith.—Experiments with piperidine-piperidyl-di-thio-carbamate were described. Previous work by Whitby without an activator was repeated but in the presence of zinc oxide. The rate of cure was greatly increased. This is a very powerful accelerator.

An Improved Oven for Accelerated Aging of Rubber: By C. W. Sanderson.—A small oven mounted in an oil bath for accurately maintaining temperatures while dry preheated air is passed through was described.

An Apparatus and Method for Abrasion Tests on

Rubber Compounds: By J. C. Sproull and W. W. Evans. Test-pieces are mounted on a shaft which is revolved in carborundum dust. Abrasion values which are comparable to road tests were said to be obtained by the use of this apparatus.

The Determination of True Free Sulphur and True Coefficient of Vulcanization in Vulcanized Rubber, II: By W. J. Kelly.—An extension of work already published. The author eliminates sulphur combined with pigments, resins and proteins. This work had to do with stocks containing zinc oxide, hexamethyline tetramine, etc.

The Solubility of Sulphur in Rubber: By C. S. Venable and C. D. Green.—Solubility of sulphur at 55, 75 and 95 deg. C. investigated. The solubility increases with temperature, and with increase in coefficient of vulcanization.

Determining Temperatures in Tires.—A simple method for determining temperatures in tires was described by Frank G. Breyer. An awl with a hole bored through the head is used as a needle. The hot junction of the thermocouple is inserted in the hole in the awl. The couple is put in place by merely sticking the awl into the tire and withdrawing it. Mr. Breyer offered to supply the rubber trade with these awls and tested thermocouples at a very reasonable figure. He also mentioned that his company (New Jersey Zinc Co.) would supply those who are studying mechanism of vulcanization, acceleration, etc., with chemically pure zinc oxide.

General Discussions

General discussions were held on: Accelerated Aging Tests, Mechanism of the Vulcanization of Rubber, Methods of Plotting Physical Testing Data.

Accelerated Aging Tests: Led by W. W. Evans.—The recently published article by W. C. Geer and W. W. Evans on "Ten Years' Experience With Accelerated Aging Tests" was discussed. There was a wide divergence of opinion as to temperature and other conditions of test, and also as to the actual value of such tests. The majority favored 70 deg. C. and circulation of air. An interesting test was described by A. A. Somerville. Test pieces are placed in a Mason jar and immersed in boiling water. During the first stages of the test oxidation is a factor. Later the oxygen disappears and the effect of heat alone is noted.

The Mechanism of Vulcanization of Rubber: Remarks by C. W. Bedford, G. D. Kratz, P. I. Murrill and others may be summarized in the statement that vulcanization is brought about by the action of sulphur carriers which are usually polysulphides. The carrier adds on sulphur, reacts with rubber, is split off, leaving the sulphur attached to the rubber. The process is repeated until there is no more sulphur or the temperature drops below the point where the reaction is possible.

Methods of Plotting Physical Testing Data: Led by W. W. Vogt.—An extremely simple and convenient method of visualizing and comparing the data contained in several stress-strain curves was presented. Load is plotted on the *Y* axis and time of cure or volume of filler on the *X* axis. The loads necessary to produce 100, 200, 300, etc., per cent elongation for the various stocks are plotted, and smooth curves are drawn. The method has the advantage that there is no overlapping of curves on the chart, and yet all points of interest are unobscured.

Capacity of Electrolytic Zinc Plants

At the present time the potential aggregate production of electrolytic zinc for the world amounts to approximately 125,000 tons, or 250,000,000 lb., per year. This is divided about as follows:

	Tons
Anaconda Copper Mining Co., Great Falls	55,000 to 60,000
Consolidated Mining & Smelting Co., Trail	20,000 to 25,000
Electrolytic Zinc Co. of Australasia	30,000 to 40,000
Judge Mining & Smelting Co., Park City	2,500
Brunner, Mond & Co., England	1,700

The record production for Anaconda's plant was made in July, 1920, when a total of 11,801,662 lb. of cathodes was drawn. For Great Falls conditions this does not all represent marketable zinc, inasmuch as about 8 per cent of the cathode production must be blown into zinc dust for removal of copper and cadmium from the solutions. It should be borne in mind, however, that if the Great Falls plant had a copper-free concentrate to treat this would have very nearly represented net production, as on such concentrates probably not over 15 per cent as much zinc dust would have been required for purification. While, therefore, the Great Falls Plant is rated at only about 110,000,000 lb. per annum, this means production from the relatively impure and cupreous concentrates on which it operates. The maximum output of the tank house has been demonstrated to be at the rate of 140,000,000 lb. per year, or 193 tons per day, and it is probable that under favorable conditions, operating on concentrates such as are produced in the Joplin districts, the equipment at Great Falls could roast, leach and electrolyze sufficient concentrate for a production of 200 tons of zinc per day.

Casein Glues Exceptionally Durable in Damp Places*

Casein glues are as a class more water-resistant than animal and vegetable glues, but they are not, strictly speaking, waterproof. There is no glue that is waterproof in the sense that it is absolutely unaffected by water after a long immersion. Nevertheless there are casein glues that are so water-resistant that plywood glued with them will withstand soaking for many weeks in water or exposure for many months to a warm, damp atmosphere. Under similar conditions animal and vegetable glues would soon lose their strength.

When casein glue joints are kept fairly dry, they can be expected to retain their strength and remain unchanged for an indefinite period, as is the case with animal and vegetable glues. Water-resistant casein glue in a joint, kept constantly wet, will after a long time weaken, but it will ordinarily regain a great deal of its strength if the joint is dried. In a study aimed to discover the reason why casein glues ultimately decompose when kept moist, it was found that under certain conditions the decomposition seemed to be due to a hydrolysis of the casein, undoubtedly brought about by the sodium hydroxide always present in casein glues.

This explanation has been misunderstood to some extent. It should not be taken to mean that casein glues are unreliable and not durable enough for use in manufacturing plywood and other glued products. On the contrary, casein glues are considered as permanent as any under dry conditions, and the water-resistant casein glues are more permanent than animal or vegetable glues under wet or damp conditions.

*From U. S. Forest Products Laboratory *Technical Notes.*

Calculation of Equilibrium in Metallurgical Reactions

Thermochemical Computations Much Used by Physical Chemists, but Relatively Unknown to Metallurgists, Are Applied to Important Furnace Reactions — Relative Stability, Danger of Oxidation, Ease of Reduction, and Equilibrium Conditions Can Be Inferred From Thermal Data

BY PAUL D. MERICA

METALLURGISTS are not infrequently called upon to answer questions concerning the nature of chemical reactions occurring in the various processes of smelting or refining in which they are interested and the extent to which and direction in which these reactions are influenced by change of temperature or by the addition of other materials either in the solid, liquid or gaseous form. In answering such questions recourse may often be had to the results of experience in plant operation or of direct experimentation with the reactions in question, and upon these concrete facts may of course be built the soundest and most satisfactory answer. Often, however, our experience may not be in such form as to be exactly applicable to the particular problem and we must resort to other more general and theoretical considerations for a solution of it.

WHAT REACTION WILL OCCUR

Will a certain chemical reaction proceed readily at a temperature of 1,500 deg. F.? A well-known rough and ready aid to the chemist or metallurgist in answering such a question is the consideration of the heat of reaction, it being assumed that if the reaction is accompanied by evolution of heat it will proceed, but that if accompanied by absorption of heat it will not. The heat of reaction may be readily calculated from the heats of formation of the compounds entering into it, data which are available in Richards' "Metallurgical Calculations" and Liddell's "Metallurgists' and Chemists' Handbook." It is perhaps also well known that considerations of this sort will lead often to entirely incorrect conclusions, particularly in the case of reactions involving gases and proceeding at high temperatures—reactions in which the metallurgist is peculiarly interested. The use of this simple criterion for deciding whether a reaction will or will not proceed must be restricted to the case of reactions involving only pure solids and liquids other than solutions—i.e., the so-called condensed systems, but in such cases gives conclusions not far from the truth in the majority of cases.

Modern developments of theoretical chemistry have shown the existence of further relations which we may utilize to extend somewhat our powers of theoretical prediction, and it is the purpose of this paper to describe and illustrate the use of methods based upon these relations and to show what are their scope and limitations and upon what fundamental laws and hypotheses they are based. For although the utilization of these methods has become somewhat familiar to the physical chemist, it does not appear that their value has become apparent to metallurgists in general or that any description of them has been given in metallurgical literature. It is therefore with the excuse of making these methods available to metallurgists that the author ventures to set down the discussion which follows, much of which, including the fundamental theory, is not new or original with him. He has himself found them of definite, practical value and does not doubt that they can be as valuable to others.

One fact must be emphasized at the very outset—namely, that the discussion to follow deals entirely with the equilibrium of chemical reactions and is based upon simple thermodynamic laws modified by a few assumptions. Results of such calculations of chemical reactions as are described will enable one to make definite predictions whether a chemical reaction should proceed in a certain direction or in which direction it will proceed if any chemical change takes place, but it will not enable one necessarily to predict whether a reaction which *should* proceed *will* proceed. It is a familiar fact that many reactions which should go on in a certain way according to their affinities will not do so owing to lack of mobility or velocity of the molecules or to other as yet little understood reasons. For example, hydrogen and oxygen will not unite at ordinary temperatures to form water with measurable velocity, although water is more stable than a mixture of its two component gases. Generally speaking, an increase of temperature relieves this frictional effect or resistance to reaction, probably by increasing the vibrational or translational velocity of the molecules, so that metallurgical reactions at high temperatures usually proceed to the chemical or thermodynamic equilibrium with which this discussion is concerned.

THE AFFINITY OF CHEMICAL REACTIONS

The amount of free energy—available as mechanical or electrical energy—which may be obtained from isothermal, reversible execution of a chemical reaction between molar amounts of the reacting substances is the exact measure of the affinity of that reaction and may be considered identical with it. It may be measured in calories, watts or foot-pounds; if it is positive—i.e., corresponding to evolution of free energy—the reaction should proceed; if negative, the reverse reaction should proceed; if it is zero, the reacting substances are in equilibrium and no chemical change will take place. The affinity of a reaction is not equal, generally speaking, to its heat of reaction; these two quantities are connected by the following relation based alone upon the two laws of thermodynamics:

$$A - Q = T \frac{dA}{dT} \qquad (1)$$

where

A = the affinity or free energy of the reaction.
Q = the heat of the reaction.
T = the absolute temperature.

$\frac{dA}{dT_v}$ = the derivative of A to T at constant volume.

It is evident that unless $\frac{dA}{dT_v}$ is zero the free energy cannot be equal to the heat of reaction, but may be either greater or less than it.

Now our handbooks do not contain experimentally determined values of the free energy or affinity of reactions and only to a limited extent are such values to be found in our chemical literature. The principal reason is that they are difficult to determine directly. Handbooks do, however, contain extensive data on the heats of formation of chemical compounds from which heats of reaction Q may easily be computed. If we were able to calculate the value of the right-hand term of equation 1 we could always compute from the known heats of reaction the free energies or affinities of chemical reactions and our task of attempting to predict the course of these reactions would be completed.

The most promising method of making this calculation appears to be that based upon an assumption first made and discussed by Nernst,[1] of which the direct statement here would mean little and is omitted. It is sufficient to say that although the assumption has only a limited theoretical basis, it has been quite thoroughly tested out in comparison with the direct results of experience and observation in various and widely different fields and appears to have established itself as a reasonably accurate hypothesis.

Upon the basis of equation 1 and this assumption A and Q may be shown to have the following relation:

$$Q = Q_o + \Sigma bT^2 + \Sigma cT^3 + \ldots\ldots \quad (2)$$

$$A = Q_o - \Sigma bT^2 - \Sigma cT^3 - \ldots\ldots \quad (3)$$

where

Q = the molar heat of reaction at constant volume at the absolute temperature T, considered positive if heat is evolved in the reaction. Q_o, the same at absolute zero.

A = the molar free energy or affinity of the reaction at the same temperature considered in the same sense.

Σ = summation of reacting mols (considered positive) and resultant mols (considered negative).

b and c = coefficients depending upon the change of the specific heats of the reacting compounds with temperature.

From Kirchoff's law and equation 2

$$\Sigma S_T = \frac{dQ}{dT} = 2\Sigma bT + 3\Sigma cT^2 + \ldots \quad (4)$$

where S_T = the true molar heat of each compound at the absolute temperature T and constant volume.

These liquids hold only for the case that pure solids and liquids (no solutions) alone take part in the reaction. It is seen that to compute values of A, the affinity, it requires only a knowledge of the heat of reaction at any temperature together with the values of the specific or molar heats of the reacting and resulting compounds at the same or several temperatures. The latter data are also available in reference and hand books, although not as extensive as those on heats of formation.

Metallurgical reactions involving only pure solids and liquids are rare, but the following examples may serve to illustrate the application of the above equations.

[1] Sitzungs-Berichte d. Kgl. Preuss. Akad. d. Wissenschaft, 1906, p. 933.

Reduction of silver sulphide by mercury is supposed to proceed in amalgamation by the Washoe process.

$$Ag_2S + Hg = HgS + 2Ag + 7{,}600 \text{ calories} \quad (5)$$

molar heat of $Ag_2S = 248 \times 0.0746 = 18.5$

$Hg = 200 \times 0.033 = 6.6$

25.1

$HgS = 232 \times 0.0512 = 11.9$

$2Ag = 2 \times 108 \times 0.056 = 12.1$

24.0

If terms in T^3, T^4 .... be neglected, equation 4 becomes

$$\Sigma S_T = 2\Sigma bT$$

whence

$$\Sigma b = \frac{\Sigma S_T}{2T}$$

and for the reaction 5 at ordinary temperature

$$\Sigma b = \frac{25.1 - 24.0}{2 \times 300} = + \frac{1.1}{600} = + 0.0018$$

Substituting in 2

$$7{,}600 = Q_o + 0.0018 \times 300 \times 300$$

$$Q_o = 7{,}438$$

Hence, from 3

$$A = 7{,}438 - 0.0018\ T^2$$

The affinity of this reaction is positive, but its value decreases with increasing temperature.

Again, consider the reaction

$$PbS + Fe = Pb + FeS + 3{,}800 \text{ calories}$$

$$\Sigma b = \frac{12.16 + 6.67 - 6.4 - 11.9}{2 \times 300} = + 0.001$$

$$3{,}800 = Q_o + 0.001 \times 300^2 \quad Q_o = 3{,}710$$

therefore $A = 3{,}710 - 0.001T^2$

It is seen that the values of A for these reactions differ but little from those of Q, which is generally the case in reactions involving no gases or solutions. For this reason it is generally sufficient in such cases to consider only the heat of reaction as indicating sufficiently accurately the affinity of the reaction.

Gas Reactions

Most metallurgical reactions involve gases and it is to such reactions that the following methods of calculation are particularly applicable. Equilibrium in chemical reactions in which gases take part may be described completely, as is well known, by a statement of the equilibrium pressures of the several gases which are required to maintain the reacting system without chemical change. "The intensity of an action varies as the concentration of the reacting molecular species." Thus in the reaction by which water gas produced

$$H_2O + C = H_2 + CO \quad (6)$$

the tendency of the reaction to proceed to the right equals some constant times the partial pressure of the water vapor—that is, equals $K \times P_{H_2O}$. On the other hand, the tendency to reverse and proceed to the left equals $K_2 \times P_{H_2} \times P_{CO}$. At equilibrium these tendencies are equal; hence

$$K_p = \frac{P_{H_2} \times P_{CO}}{P_{H_2O}} \quad (7)$$

in which K_p is known as the equilibrium constant of the reaction and depends only on the temperature. If it is known for any temperatures, the equilibrium pressures of these gases may be calculated for those temperatures.

Quite generally a reaction may involve pure solids or liquids (not solutions) as participants as well as gases and may be schematically represented as follows:

$$lL + mM + \ldots\ldots\ldots qQ + rR + \ldots\ldots = uU + vV + \ldots\ldots xX + yY + \ldots\ldots \quad (8)$$

where the lower case letters are integers representing the number of molecules taking place in the reaction, and

$L, M, \ldots\ldots U, V \ldots\ldots$ are solid or liquid compounds

$Q, R, \ldots\ldots X, Y \ldots\ldots$ are gaseous molecules.

For this reaction at any given temperature the following relation similar to 7 will apply:

$$K_p = \frac{p_X{}^x p_Y{}^y \ldots\ldots}{p_Q{}^q p_R{}^r \ldots\ldots} \quad (9)$$

If the value of K_p for any temperature is known, the equilibrium gas pressures for the reaction can be calculated for this temperature. These pressures are conveniently expressed in atmospheres or fractions thereof, and assuming that the gases obey the simple gas laws and the partial pressure in a mixture existing at atmospheric pressure is one atmosphere times the percentage composition. Thus the pressure for CO_2 in combustion gases under atmospheric pressure containing 12 per cent of CO_2 is 0.12 atmosphere.

On the basis of the Nernst theorem and one or two other minor assumptions—namely, that the gases obey the simple gas laws and that the molecular heat of compounds at absolute zero is exactly additive—the relations shown in equations 10 and 11 may be derived. In these the equilibrium constant, K_p, is expressed in terms of the absolute temperature, the heat of reaction, coefficients depending on the rate of change of the specific heat of the compounds with temperature, and the so-called chemical constants (C). The values of these constants (C) have been computed by Nernst and are dependent on the vaporization characteristics of the gases taking part in the reaction; they are given in Table I. Other data required for the computation of K_p from these equations are found in handbooks. It will not be attempted here to derive these equations; those interested in this derivation may consult such references as Sackur-Gibson, "A Textbook of Termo-Chemistry and Thermodynamics," McMillan & Co., 1917, or Lewis, "A System of Physical Chemistry," Longmans, Green & Co., 1918.

$$\log K_p = \frac{Q_o}{4.57T} - \Sigma g\, 1.75 \log T - \left(\frac{\Sigma b + \Sigma\beta}{4.57}\right) T - \left(\frac{\Sigma c + \Sigma\gamma}{9.14}\right) T^2 \ldots\ldots - \Sigma C \quad (10)$$

where $$\Sigma S + \Sigma G = 3.5\Sigma g + 2T(\Sigma b + \Sigma\beta) + 3T^2(\Sigma c + \Sigma\gamma) \quad (10a)$$

and $$Q_o = Q_p - \Sigma g 3.5T - T^2(\Sigma b + \Sigma\beta) - T^3\frac{(\Sigma c + \Sigma\gamma)}{2} \quad (10b)$$

where

Q_o = the molar heat of the reaction at absolute zero;

Q_p = the molar heat of reaction at constant pressure at the absolute temperature, T, considered positive if heat is evolved in the reaction. This is the value which is computed from values of heats of formation found in handbooks;

S = molar heat of each solid or liquid substance;

G = molar heat (at constant pressure) of each gas;

$b, c, \ldots$ = coefficient relating to solid or liquid substances;

$\beta, \gamma, \ldots$ = coefficients relating to gaseous substances;

and ΣS = the summation of true molar heats of all solid and liquid participants; reacting mols are considered positive, resulting ones negative. The molar heat equals the specific heat multiplied by the molecular weight;

ΣG = summation in the same sense of the true molar heats at constant pressure of all gases taking part in the reaction;

Σg = summation in the same sense of all gaseous molecules;

ΣC = summation in the same sense of the chemical constants of all gases taking part in the reaction; values are given in Table I.

TABLE I. VALUES OF THE CHEMICAL CONSTANT, C, COMPUTED BY NERNST*

Hydrogen (H_2)	1.6	Nitrous oxide (N_2O)	3.3
Methane (CH_4)	2.5	Hydrogen sulphide (H_2S)	3.0
Nitrogen (N_2)	2.6	Sulphur dioxide (SO_2)	3.3
Oxygen (O_2)	2.8	Carbon dioxide (CO_2)	3.2
Carbon monoxide (CO)	3.5	Carbon bisulphide (CS_2)	3.1
Chlorine (Cl_2)	3.1	Ammonia (NH_3)	3.3
Iodine (I_2)	3.9	Water vapor (H_2O)	3.6
Hydrochloric acid (HCl)	3.0	Carbon tetrachloride (CCl_4)	3.1
Hydriodic acid (HI)	3.4	Chloroform ($CHCl_3$)	3.2
Nitric oxide (NO)	3.5	Benzene (C_6H_6)	4.0

**Zeit. Electrochemie*, vol. 15, p. 687; 1909.

Our information concerning specific heats is generally not sufficient for us to evaluate the coefficients c and γ; if we neglect this term in the equations 10 they take the following form:

$$\log K_p = \frac{Q_o}{4.57T} - \Sigma g 1.75 \log T - \frac{\Sigma b + \Sigma\beta}{4.57} T - \Sigma C \quad (11)$$

with corresponding omission of the last terms in 10a and 10b. Equations 10a and 10b also become

$$\Sigma b + \Sigma\beta = \frac{\Sigma S + \Sigma G - 3.5\Sigma g}{2T} \quad (11a)$$

and $$Q_o = Q_p - 3.5T\Sigma g - T^2(\Sigma b + \Sigma\beta) \quad (11b)$$

For still more approximate calculations, which are nevertheless of value in many cases, we may neglect also the coefficients b and β, and either assume that the heat of reaction at absolute zero, Q_o, is equal to the value (Q_p) obtained from heats of formation, or consider that

$$Q_o = Q_p - \Sigma g 3.5T \quad (12)$$

In the latter case equation 11 takes the form:

$$\log K_p = \frac{Q_o}{4.57T} - \Sigma g\ 1.75 \log T - \Sigma v C \quad (12a)$$

These equations, which may seem at first sight rather formidable, are in reality not difficult to evaluate with a little practice. A few illustrations may be given of their practical application.

Equilibrium in Blast-Furnace Gas

What is the equilibrium composition of blast-furnace gases, CO and CO_2, assuming that there is a slight excess of coke in the furnace?

$$C + CO_2 = 2CO - 38{,}880 \text{ calories} \quad (13)$$

for which $K_p = \frac{p^2_{co}}{p_{co_2}} = \frac{p^2_{co}}{1 - p_{co}}$ (13a)

(if $p_{co} + p_{co_2} = 100$ per cent; i.e., neglecting nitrogen).

We might judge from the negative heat of reaction that no CO could be formed in it, which is of course not true; this is a good illustration of the false conclusions to which one may be led by the application of this criterion.

Specific heat of carbon at about 25° C. = 0.16
Molar heat of carbon at about 25° C. = $0.16 \times 12 = 1.92$

Specific heat of CO_2, constant pressure, about 25° C. = 0.201
Molar heat of CO_2, constant pressure, about 25° C. = $0.201 \times 44 = 8.85$

Specific heat of CO, constant pressure, about 25° C. = 0.243
Molar heat of CO, constant pressure, about 25° C. = $0.243 \times 28 = 6.82$

ΣC (from Table I) $= 3.2 - 2 \times 3.5 = -3.8$

From 10a and 10b omitting term in T^2

$$\Sigma b + \Sigma \beta = \frac{\Sigma \delta + \Sigma G - 3.5 \Sigma g}{2T}$$

$$= \frac{(1.97) + (8.85 - 2 \times 6.82) - 3.5(+1-2)}{2 \times 300} = +0.001$$

$$Q_o = Q_p - \Sigma I\, 3.5T - T^2(\Sigma b + \Sigma \beta)$$
$$= -38880 - (-1)\, 3.5 \times 300 - 300 \times 300 \times 0.001$$
$$= -37920$$

$$\text{And } \log K_p = -\frac{37970}{4.57T} + 1.75 \log T - \frac{0.001}{4.57} T + 3.8 \quad (13)$$

Table II shows the values computed from this equation for three temperatures in comparison with the values of the per cent CO and CO_2 actually observed by direct experiment.[8]

[8] G. Schraube, Diss. Berl. Tech. Hochschule, 1911.

TABLE II. COMPARISON OF EQUILIBRIUM PERCENTAGE COMPOSITION OF $CO:CO_2C$ AS CALCULATED FROM EQUATION 12 AND OBSERVED

Temperature				Per Cent of CO in Equilibrium $CO + CO_2 = 100$ per cent	
Deg. C.	Deg. Abs.	Log K_p	K_p	Calculated	Observed
700	973	+0.27	1.85	72	63.4
800	1,073	1.14	13.73	93	88.6
900	1,173	1.88	75.8	99	97.0

The agreement is good between observed and calculated values and would be better if better data on specific heats and heats of formation were available.

Chloridizing Roast

A knowledge of the temperature range of stability of chlorides and of sulphates is essential to the proper conduct of chloridizing or sulphatizing roasting. For instance, At what temperatures and under what conditions does Cu_2Cl_2 decompose?

$$Cu_2Cl_2 = 2Cu + Cl_2 - 70{,}800 \text{ calories} \quad (14)$$

Using the above equation in the short form (12a) and assuming $Q_o = Q_p$

$$\log K_p = -\frac{15{,}400}{T} + 1.75 \log T + 3.0 \quad (14a)$$

If decomposition occurs according to

$$2Cu_2Cl_2 + O_2 = 2Cu_2O + 2Cl_2 - 54{,}000 \text{ calories} \quad (15)$$

$$\log K_p = 2 \log P_{HCl} \log P_{O_2}$$
$$= -\frac{11{,}800}{T} + 1.75 \log T + 3.2 \quad (15a)$$

Or if water vapor is the oxidizer:

$$Cu_2Cl_2 + H_2O = Cu_2O + 2HCl - 41{,}600 \text{ calories} \quad (16)$$

$$\log K_p = 2 \log P_{HCl_2} \log P_{O_2}$$
$$= -\frac{9{,}100}{T} + 1.75 \log T + 2.4 \quad (16a)$$

There is evidently little direct decomposition of Cu_2Cl_2 below about 2,000 deg. F. at which the equilibrium pressure of Cl_2 for the reaction 14a is about 1,000 parts per million. However, in the presence of air or of water vapor the decomposition according to the equations 15a and 16a will proceed at lower temperatures. If we assume 10 per cent of O_2 in the combustion gases (for purposes of calculation), it is found from these equations that at 1,600 deg. F. the equilibrium pressure of Cl_2 from reaction 15 will be 4,200 parts per million, or 0.42 per cent. When 10 per cent of water vapor is present, that of HCl will be 2.5 per cent. At these pressures the cuprous chloride would rapidly decompose in a stream of combustion gases. It is evident from the equations that the higher the temperature the less stable is the chloride, particularly in the presence of water or oxygen. It is of course well known that this chloride does decompose within this approximate range of temperatures.

Stability of Sulphates

What is the comparative temperature stability of calcium and of ferric sulphate? They both decompose into oxide and sulphur trioxide, which in turn is decomposed into $SO_2 + O_2$. We may take both decompositions and equilibria into account in the calculations.

$$CaSO_4 = CaO + SO_3 - 94{,}000 \text{ calories} \quad (17)$$

$$\log K_p = \log P_{SO_3} = -\frac{20{,}500}{T} + 1.75 \log T + 3.5 \quad (17a)$$

$$Fe_2(SO_4)_3 = Fe_2O_3 + 3SO_3 - 129{,}400 \text{ calories (assuming heat of formation of the sulphate to be 600,000 calories)} \quad (18)$$

$$\log K_p = 3 \log P_{SO_3} = -\frac{28{,}300}{T} + 5.25 \log T + 10.5 \quad (18a)$$

$$2SO_3 = 2SO_2 + O_2 - 45{,}280 \text{ calories} \quad (19)$$

$$\log K_p = 2 \log P_{SO_2} + \log P_{O_2} - 2 \log P_{SO_3}$$
$$= -\frac{9{,}910}{T} + 1.75 \log T + 2.4 \quad (19a)$$

We wish to calculate the temperature at which these two sulphates are in equilibrium with a combustion gas carrying 1 per cent each of SO_2 and O_2. Equation 19a becomes:

$$-2 \log P_{SO_3} = +4 + 2 - \frac{9910}{T} + 1.75 \log T + 2.4 \quad (20)$$

Equating the value of $\log P_{SO_3}$ of equation 20 first to that obtained from equation 17a and then to that from equation 18a and solving in each case for T, it is found that calcium sulphate is in stable equilibrium with 1 per cent each of SO_2 and O_2 at 1,307 deg. C. Ferric sulphate is stable under the same conditions at 649 deg. C. There is thus a marked difference in the stability of these two sulphates, which is of course well known.

Oxidation and Reduction

It is well known that there is a marked difference in the ease with which different metallic oxides are reduced to the corresponding metal. If we accomplish this reduction with a mixture of carbon monoxide and dioxide, which is generally the case, the ratio per cent CO to per cent CO_2 necessary to effect reduction may

be taken as a numerical index of the ease or difficulty of this reduction. If this ratio is high, the reduction is difficult; if low, easy.

Let us compare the ease of reduction of ferrous and of cuprous oxide by such a mixture.

$$FeO + CO = Fe + CO_2 + 2{,}340 \text{ calories} \quad (21)$$

$$Cu_2O + CO = 2Cu + CO_2 + 24{,}240 \text{ calories} \quad (22)$$

Assume molar heats taken from handbook data as follows: Cu_2O, 15.87; FeO, 10.5; Cu, 5.91; Fe, 5.9; CO, 6.74; CO_2, 8.38. We then find the following equilibrium equations:

$$\log K_p = \log P_{CO_2} - \log P_{CO} = 630/T - 0.0011T - 0.3 \quad (21a)$$

$$\log K_p = \log P_{CO_2} - \log P_{CO} = 5220/T - 0.00088T - 0.3 \quad (22a)$$

(Note that Σg becomes zero when there are as many gas molecules on one side of the equation as on the other.)

We see that a mixture of 96 per cent CO and 4 per cent CO_2 is necessary to reduce FeO at 1,400 deg. abs. (2,060 deg. F.), whereas at the same temperature a mixture of 0.6 per cent of CO and 99.4 per cent CO_2 will reduce Cu_2O.

These illustrations have shown the possibility of predicting the equilibrium conditions in any reaction entirely from thermal data (heats of formation and specific heats) together with the values of the chemical constants.

If we are fortunate enough to have determined the actual equilibrium at any temperature by independent experiment, we may use the same equations to determine it at any other temperature and of course with a considerable increase of accuracy over the previous method, for which no direct data are used. Use preferably formula 11 for this purpose. The determined value of K_p for temperature T_1 is K_1. Substitute values of T_1 and T_2, K_1 and K_2 in formula 11 and subtract one from the other.

$$\log K_2 - \log K_1 = \frac{Q_o}{4.57\left(\frac{1}{T_2} - \frac{1}{T_1}\right)} - \Sigma g 1.75(\log T_2 - \log T_1) - \left(\frac{\Sigma b + \Sigma \beta}{4.57}\right)(T_2 - T_1) \quad (23)$$

The method of application of this equation is obvious and is a most useful one whenever any direct information is available concerning equilibrium of any reaction.

From Table II it is noted that at 700 deg. C. there was equilibrium in reaction 13 when there was 63.4 per cent CO + 36.6 per cent CO_2. Substituting these values, we may determine equilibrium at 900 deg. C. thus:

$$K_p \text{ for 700 deg. C.} = \frac{63.4^2}{36.6} = 3.0;$$

$$\log K_p = 0.477;$$

$$0.477 - \log K_1 = -8{,}310\left(\frac{1}{973} - \frac{1}{1173}\right) + 1.75(2.988 - 3.069) - 0.00022\ (-200)$$

$$\log K_1 = 2.037;$$

$$K_1 = 109.$$

Whence $p_{CO} = 99$ per cent;

$p_{CO_2} = 1$ per cent.

Thus at 900 deg. C. we calculate that there must be 99 per cent of CO and 1 per cent of CO_2 for equilibrium; these values agree closely with the observed ones given in Table II.

Usefulness of Mathematical Methods

The more values of the equilibrium constant, K_p, we have as the result of direct determination the more accurately we can write equation 10 and consequently know the value of K_p for other temperatures. If, for example, two values of the constant are determined directly, they may be used to determine the coefficients in equation 11.

It may be pointed out here that the equilibria of many reactions of great interest to metallurgists such as

$$CO_2 + H_2 = H_2O + CO$$
$$2CO + O_2 = 2CO_2$$
$$2H_2 + O_2 = 2H_2O$$
$$2CO = C + CO_2$$
$$2H_2 + S_2 = 2H_2S$$
$$O_2 + 4HCl = 2H_2O + 2Cl_2$$
$$2SO_2 + O_2 = 2SO_3$$

have been studied experimentally; the results of these investigations are for the most part scattered throughout current periodical literature for the last fifteen years. It would be well if they could be assembled for ready reference in the reference and hand books with which metallurgists are familiar, as they are of great practical value. Many of these results may be found in the book by Lewis mentioned above as well as in Jellinek, "Physikalische Chemie der Gasreaktionen," and Haber, "Thermodynamik der Technischen Gasreaktionen."

In conclusion, it must be pointed out that the calculation of equilibrium as described above is subject to restrictive limitations. It has already been stated that the equations 10, 11 and 12 are not applicable without alteration to chemical reactions involving solid or liquid solutions, except in a very approximate manner. Furthermore, the results of such calculations from purely thermal data are necessarily not more accurate than the data on which they are based and our present knowledge of the specific heats of chemical compounds leaves much to be desired; in particular our knowledge of these specific heats at higher and lower temperatures is very meager. The author must confess that it was not the least important purpose he had in mind in writing this article to emphasize the need of the metallurgical and chemical industries for new and more accurate data on specific heats of chemical compounds, covering the widest possible temperature ranges and to make an appeal to those institutions having the equipment of these determinations to undertake some systematic work along these lines. The results of such work would have a wide usefulness and would constitute a most valuable service to our metallurgical and chemical industries.

Foreign Portland Cement Specifications

The Bureau of Standards has recently completed a summary of the portland cement specifications of various countries. This includes not only the principal requirements but also many of the details of methods of tests, details which are frequently of great importance when considering the specifications of some of the countries. However, for ready reference, the principal physical and chemical requirements have been assembled in a single chart, 16 x 22 in., copies of which may be obtained by addressing the bureau.

The Constitution of Martensite and Troostite

Hardness of Martensite Mainly Due to Fine-Grained Alpha Iron—Martensite Also Contains Carbide in Same Condition as It Existed in Austenite—Such Carbide Contracts Into True Cementite Particles to Form Troostite

By D. J. McADAM, Jr.
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In THE paper on "The Slip Interference Theory of the Hardening of Metals," by Jeffries and Archer,[1] these authors have made a valuable contribution to the science of metallography. Their theory of slip interference as a general cause of the strengthening and hardening of metals has made it possible to classify and explain many facts hitherto not understood.

The effect of small, hard, disconnected particles in increasing the strength of metals has thus been explained. For example, the mechanism of the hardening of duralumin by means of the submicroscopic particles of $CuAl_2$ is now clear.

Are Transformations in Carbon Steels Different Than in Alloy Steels?

The authors' explanation of the constitution of martensite, however, would seem to require some application and possibly modification in order that all the phenomena of the hardening of steel may be properly classified. The section headings, for example, "Martensite Is Alpha Iron" and "No Cementite in Martensite," on pages 1065 and 1066 of the authors' article, at once raise the question, Do these assertions apply to

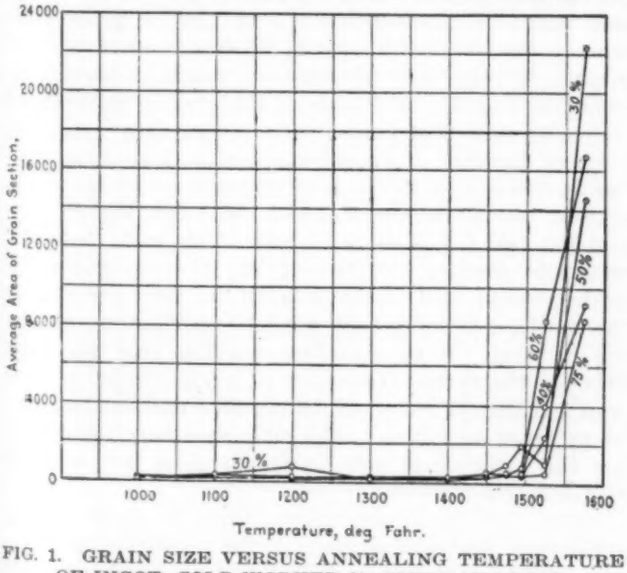


FIG. 1. GRAIN SIZE VERSUS ANNEALING TEMPERATURE OF INGOT, COLD-WORKED VARIOUS AMOUNTS

all microstructures that are now generally known as martensite? The authors seem to assert that "martensites" of all chemical compositions, whether produced during cooling or tempering of steel, consist of alpha iron with carbon in solid solution. Such a statement, it seems to the writer, does not correctly describe the constitution of every so-called martensite.

When austenitic alloy steels, for example, are reheated or cold-worked, the first transformation products have a typical, "martensitic," structure[2] which is usually called "martensite." In such steels, when the carbon percentage is sufficiently high, the deposition of carbides on tempering precedes and accompanies the transformation of iron from the gamma to the alpha condition. The first transformation products, therefore, contain cementite. In austenitic manganese steel, for example, according to the authors' own description of the transformation process, the first change on reheating consists in the deposition of carbides. The order of transformation in such steels is thus entirely different from that described by the authors under the heading "No Cementite in Martensite."

Evidently, therefore, the "martensites" produced by tempering austenitic steels may contain cementite. Are all the martensites produced during the cooling of steels different in constitution from the martensites produced by tempering? This subject deserves careful consideration in relation to the probable space lattice arrangements and various physical properties of quenched steels.

Influence of Grain Refinement in Alpha Iron

In discussing the subject of the constitution of martensite, consideration will first be given to Jeffries and Archer's theory that the hardness of quenched steel is due chiefly to the presence of exceedingly fine-grained alpha iron. In this discussion, for the sake of brevity, all non-gamma iron will be called alpha iron. Careful study of the authors' theory has led the writer to the conclusion that it is valid, at least as applied to hypoeutectoid steels. To account for the hardness of these quenched steels, it is not necessary to assume the presence of cementite in martensite.

I was at the first inclined to doubt the authors' conclusion that in quenched carbon steel the ferrite can be of submicroscopic grain size while the carbon is in solid solution. In quenched "Armco" ingot iron, the ferrite grains are always visible under the microscope and are often of rather large size. How is it possible, then, that quenched steel of higher carbon percentage may be composed of submicroscopic ferrite grains with carbon in solid solution? How could carbon in solid solution obstruct grain growth of ferrite?

An investigation at the U. S. Naval Engineering Experiment Station on the influence of temperature on the grain growth of iron and published in the *Proceedings* of the American Society for Testing Materials[3] throws considerable light on this subject.

[1] CHEM. & MET. ENG., June 15, 1921, vol. 24, p. 1057.

[2] Howe, "Metallography of Steel and Cast Iron," p. 642.

[3] "Annealing Temperatures and Grain Growth," by D. J. McAdam, Jr., *Proc.*, A.S.T.M., vol. 17, Part II, 1917. "Grain Size of Iron as Affected by Temperature," by D. J. McAdam, Jr., *Proc.*, A.S.T.M., vol. 18, Part II, 1918.

Fig. 1, taken from the second of the articles describing this work, shows the effect of temperature on grain coalescence[4] of cold-worked ingot iron. As illustrated by the graphs in Fig. 1, these experiments showed that below about 1,450 deg. F. (790 deg. C.) the grain coalescence tendency is slight and is only slightly affected by temperature. From this temperature to the Ac, point, however, the grain coalescence tendency increases very rapidly with rise of temperature.

Though the experiments summarized in Fig. 1 were made primarily to show the influence of temperature on grain coalescence tendency of recrystallized ferrite after various percentages of reduction by cold-working, the results throw considerable light on the influence of temperature on the grain coalescence tendency of the alpha iron formed from austenite in the quenching of hypo-eutectoid steel. Assuming that, when hypo-eutectoid steel is quenched, there is time for the formation of alpha iron but not for the formation of cementite, the infinitesimal grains thus formed would consist of but one phase. The grain growth of this phase, being unobstructed by the presence of a second phase, would depend on the time available for growth and on the grain coalescence tendency of the phase at its temperature of formation. For any quenched hypo-eutectoid steel, therefore, the grain coalescence tendency, and hence the grain size of the phase formed from the austenite, should depend chiefly on the temperature at which the austenite is decomposed. The grain coalescence tendency, and hence the grain size, of this phase would probably not differ greatly from that of pure alpha iron, if it could be formed from pure gamma iron at the same temperature. The graphs in Fig. 1, therefore, can be used in order to draw some conclusions in regard to the probable effect of carbon content on the grain size of quenched steel. In order to study this subject, the graphs in Fig. 1 must be considered in relation to the effect of carbon on the transformation temperature of austenite and in relation to the effect of carbon on the hardness of steel.

Relation Between Brinell Hardness and Ar Transformation

Further consideration of this subject has shown a surprising correspondence between graphs of hardness and the inverted graph of transition temperatures, both drawn with carbon percentages as abscissas. These graphs are shown in Fig. 2. Graphs *A* and *B* are plotted from hardness values for quenched carbon steels listed in Table 34 of Dr. Howe's book, "The Metallography of Steel and Cast Iron." Graph *C* is an inverted representation of the effect of carbon content on the decomposition temperatures of austenite as obtained by cooling curves. The data are taken from page 168 of Sauveur's book, "The Metallography and Heat-Treatment of Iron and Steel." In this graph, line *Km* represents the Acm transitions and *Kl* represents the Ar temperatures. Curve *D* shows the maximum Brinell hardness, for any carbon content, obtained by quenching steels at various temperatures. This curve was plotted from data taken from an article by McCance.[5]

By reference to Fig. 2, it will be noticed that, up to a carbon percentage of about 0.4, increase of hardness is most rapid and bears a nearly linear relation to the carbon percentage. Above about 0.4 per cent, however, the effect of further additions of carbon has a gradually diminishing effect on the hardness, until at about 0.7 per cent the hardness has apparently reached a maximum. Further increase of carbon percentage (at least up to 1.2) neither raises nor lowers the hardness. The similarity of the hardness graphs to graph *C* of Fig. 2 indicates that the hardening effect of carbon in steel

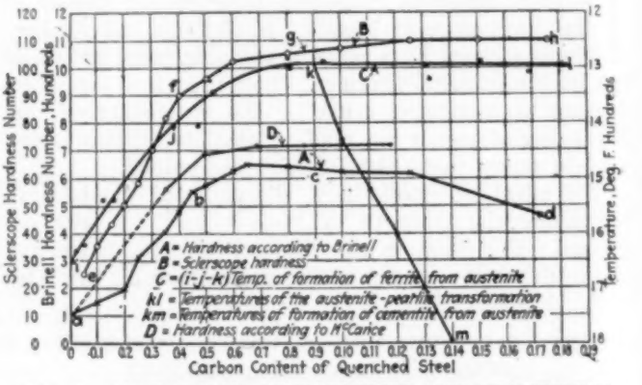

Scleroscope Hardness Number
Brinell Hardness Number, Hundreds
Temperature, Deg. F. Hundreds
A = Hardness according to Brinell
B = Scleroscope hardness
C = (i-j-k) Temp. of formation of ferrite from austenite
kl = Temperatures of the austenite-pearlite transformation
km = Temperatures of formation of cementite from austenite
D = Hardness according to McCance
Carbon Content of Quenched Steel

FIG. 2. COMPARISON OF HARDNESS AND TRANSITION TEMPERATURES OF PLAIN CARBON STEELS

is nearly proportional to the lowering of the transformation temperature of the austenite.

The rapid increase of hardness in proportion to the lowering of the Ar, transition temperature as the carbon percentage is increased from zero to about 0.4 cannot be accounted for unless it can be shown that within this range of temperature the change of grain coalescence tendency with change of temperature is very great. Within this temperature range, however, as shown in Fig. 1, the change of coalescence tendency of iron with change of temperature is unusually great. If average diameter of grain-section after 7 hours annealing is taken as a measure of coalescence tendency, the ratio of the tendencies at 1,650 and 1,450 deg. F. (900 and 790 deg. C.) is about 10 to 1. This ratio, however, would be greater the shorter the time available for grain growth, and would probably be very great after the short period of growth available during the quenching of steel. It is, therefore, possible that the ratio between the average diameter of grain-section of pure iron and that of quenched 0.4 per cent carbon steel may be as great as 600 to 1, the ratio necessary to account for the ratio of Brinell hardness values according to Mathewson's formula.

Since the transition temperature is lower during rapid than during slow cooling, the transition temperature of 0.4 per cent carbon steel during quenching would be somewhat lower than 1,450 deg. F. (790 deg. C.). Though this secondary lowering would contribute somewhat to the grain refinement of such steel, it is believed that its influence would be small in comparison with the influence of the lowering of the temperature from 1,650 to 1,450 deg. F.

The fact that increase of carbon percentage above about 0.4 has a gradually diminishing effect on hardness

[4] If cold-worked iron is gently heated there results no change in crystallization up to a certain temperature, depending upon the amount of strain previously endured by the iron—that is, the metal is "inert." Higher anneals cause complete recrystallization, if the time is sufficiently long and the temperature sufficiently high. Metal at the point of recrystallization is known as "germinant." The grain size of ingot iron after recrystallization undergoes little if any increase until a higher temperature, about 1,450 deg. F., is reached. Above this temperature there is a rapid increase in grain size with rise of temperature until the Ac_3 point is reached. This range of temperature I call the "coalescence range." The grain size reached at any temperature after a standard time of anneal may be taken as a measure of the "grain coalescence tendency."

[5] Andrew McCance, "A Contribution to the Theory of Hardening," *J. Iron & Steel Inst.*, 1914, No. 1, p. 192.

is evidently due to two factors. First, above a carbon percentage of about 0.35, the curve of austenite transformation temperatures does not fall so rapidly with increase of carbon percentage. Second, lowering of the austenite transformation temperature below about 1,450 deg. F. (790 deg. C.) has little effect on the grain coalescence tendency of the alpha iron formed from the austenite.

With a carbon percentage of about 0.7 the maximum hardness is reached. This would seem to indicate that

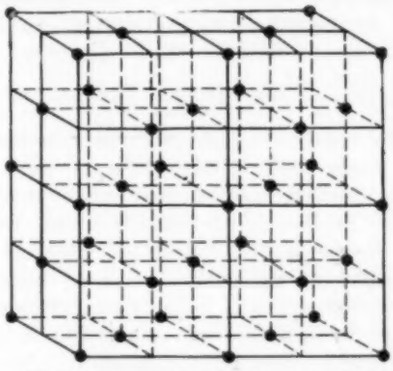


FIG. 3. FACE-CENTERED CUBIC ARRANGEMENT OF GAMMA IRON

with that carbon content grain refinement of the ferrite has reached its limit. A grain of this material, therefore, is probably the smallest possible crystal unit. Attempt at further refinement merely results in retention in the quenched steel of more or less austenite.

It seems probable, therefore, that the hardening effect of carbon, in hypo-eutectoid steel at least, is due to strengthening of the ferrite by grain refinement. The presence or absence of cementite in the martensite would probably have comparatively little effect on its hardness. Agreement with the authors' theory of hardening by grain refinement of the ferrite, therefore, does not necessarily involve agreement with their theory that

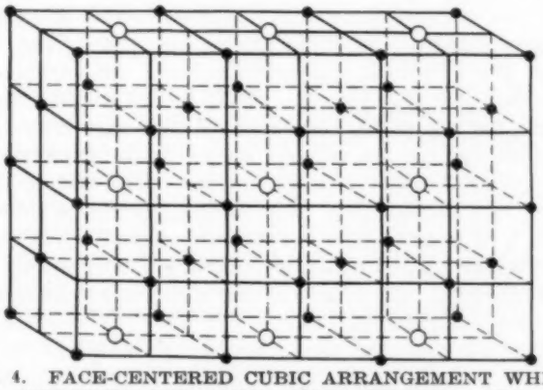


FIG. 4. FACE-CENTERED CUBIC ARRANGEMENT WHERE ONE-THIRD THE IRON ATOMS ARE REPLACED BY CARBON

"martensites" do not contain cementite. The probable condition of the carbon in martensite can be determined only by a study of the space lattice relations of austenite, alpha iron and cementite, and a study of volume, electric and magnetic relationships.

Space Lattice Relations of Austenite

The space lattice arrangement of gamma iron is illustrated by Fig. 3, in which the black dots represent iron atoms. The simplest assumption (that of the authors) for the space lattice arrangement of the solid solution of carbon in gamma iron would picture every carbon atom as taking the place of an iron atom in the gamma iron space lattice. In the austenite space lattice every carbon atom would thus exert a strong influence over twelve neighboring iron atoms. The strength of this influence is shown by the fact that by the presence of carbon the temperature of the formation of alpha iron from austenite is considerably lowered.

If enough carbon could be dissolved in the gamma iron (austenite) to produce a composition equivalent to that of cementite, the space lattice arrangement of such a composition might be represented by Fig. 4, in which the carbon atoms are represented by small circles. Each of the cubes of Fig. 4 contains a carbon atom in the center of each of two opposite faces. For each carbon atom in a group of such cubes there are three iron atoms. Such a lattice structure may, therefore, be called *potential cementite*. If the carbon atoms are more widely scattered, so that there is not more than

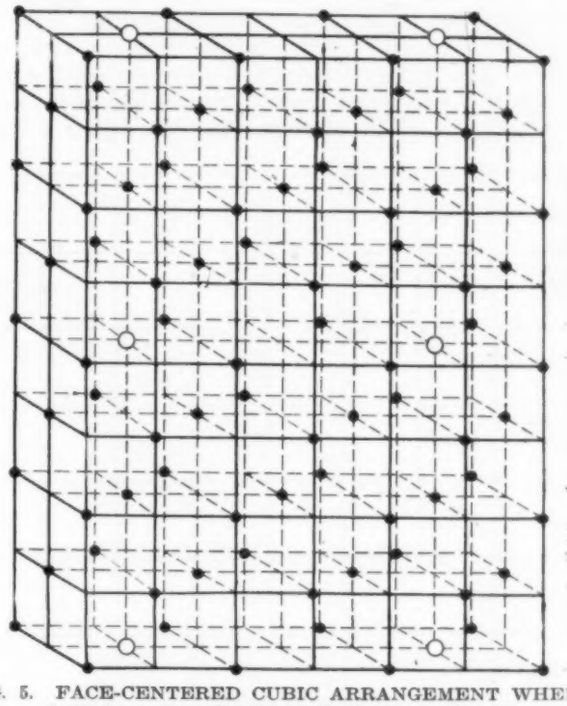


FIG. 5. FACE-CENTERED CUBIC ARRANGEMENT WHERE ONE OUT OF THIRTY-TWO IRON ATOMS IS REPLACED BY CARBON

one carbon atom in any unit cube, potential cementite could not be formed unless, by some rearrangement of atoms, two mono-carbon cubes are brought in contact.

In the lattice arrangement illustrated by Fig. 5 every pair of mono-carbon cubes is separated by a carbonless cube. Such a structure would have thirty-one iron atoms for every carbon atom and the carbon percentage would be 0.69. In a slightly closer condensation of the mono-carbon cubes, as illustrated in two dimensions in Fig. 6, there are twenty-six iron atoms to each carbon atom and the carbon percentage is 0.825, nearly that of a eutectoid steel. In the structures illustrated in Figs. 5 and 6, there is only one plane of iron atoms between any two mono-carbon cubes. A very slight movement of any carbon atom, therefore, will result in the formation of potential cementite.

In the slow cooling of hypo-eutectoid austenite, the separation of alpha iron results in bringing the carbon atoms of the austenite closer together until their concentration is about as represented in Fig. 6. In such

a structure it would seem impossible for any two carbonless cubes to pass through the rearrangement and increase in volume involved in the formation of alpha iron from austenite without thrusting two mono-carbon cubes together to form potential cementite, and finally actual cementite. With slow or moderate cooling, that is what happens; ferrite and cementite are formed simultaneously from eutectoid austenite. The influence of rapid rates of cooling will be discussed below in connection with a discussion of the volume changes involved.

With increase in carbon beyond the eutectoid percentage, mono-carbon cubes are brought in contact in increasing numbers to form potential cementite. It therefore requires higher and higher temperatures to prevent the separation of actual cementite crystals from austenite. In austenite of the maximum carbon content, containing only twelve iron atoms for every carbon atom, the steel is at the melting point.

When hyper-eutectoid steels are slowly cooled from above the Acm line, cementite forms, and this separation continues until the eutectoid composition is reached. Since on cooling hyper-eutectoid steels cementite is formed before alpha iron, and since on cooling hypo-eutectoid steels alpha iron is formed before cementite, it seems logical to conclude that in cooling eutectoid

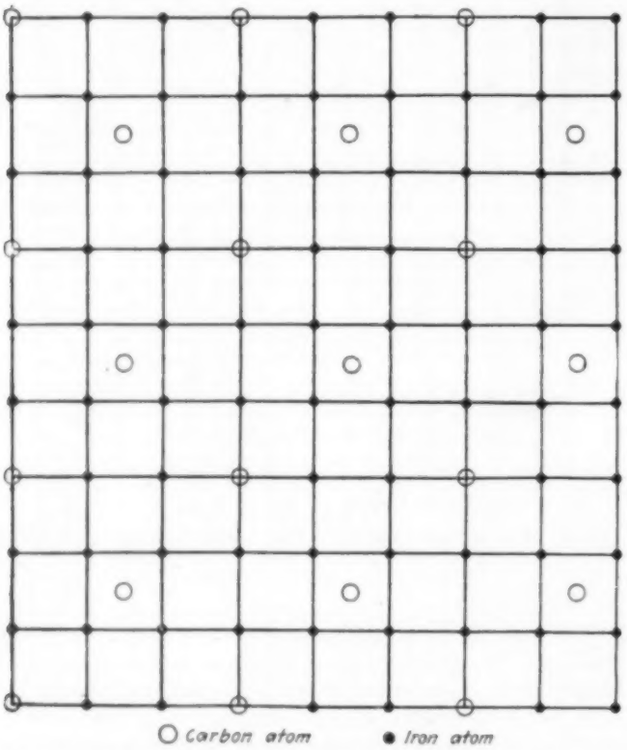


FIG. 6. PLAN OF ARRANGEMENT WHERE ONE OUT OF TWENTY-SEVEN IRON ATOMS IS REPLACED BY CARBON

steel the cementite and alpha iron are formed simultaneously. This reasoning, as well as the study of space lattice relations, therefore, leads to the conclusion that the authors are incorrect in their assertion that in eutectoid steels more migration of atoms is required for the formation of cementite than for the formation of alpha iron.

In the austenite of hyper-eutectoid steels of the higher carbon percentages the iron atoms not in the immediate sphere of influence of carbon atoms are so widely scattered that migration would be required for the formation of alpha iron. It is possible, therefore, that on quenching such steels the formation of unit cubes of alpha iron might be prevented and the excess iron might remain in atomic dispersion throughout the cementite. It is, therefore, just as reasonable to conclude that the martensite of some hyper-eutectoid steels may consist of cementite with iron in solid solution as it is to conclude that the martensite of some hypo-eutectoid steels may consist of alpha iron with carbon in solid solution.

Whether such tentative assumptions reached from study of space lattice relations alone are confirmed or disproved by recent investigations of electrical, magnetic and volume relations will be discussed below.

Volume Changes During Cooling of Steel

Electrical, magnetic and volume relations of steels quenched from various temperatures were studied by McCance.[5] DeNolly and Veyret[6] made experiments on the change in length of various steels throughout a range of temperatures. Andrew, Rippon, Miller and Wragg[7] made an extensive series of experiments on electrical, magnetic and dilatation relations of steels during slow cooling throughout a range of temperature, during tempering and after quenching. Since the data on volume relations thus obtained throw much light on the constitution of quenched steels, the writer has assembled and rearranged the essential parts of the data so as to bring out these relations most clearly. Since the dilatation experiments of DeNolly and Veyret, and of Andrew, Rippon and Miller, consisted of measurement of changes in length, the corresponding percentage changes of volume have been calculated from their results for comparison with McCance's results.

The results of these experiments show that the total volume change of any steel on slow cooling through the critical range is made up of two distinct and definite parts: an expansion due to the change from gamma to alpha iron; a contraction due to change in iron-carbide from the condition in which it occurs in austenite to cementite. The gamma-to-alpha expansion decreases and the carbide contraction increases with increase in carbon content. In steels having less than about 1 per cent, the allotropic expansion exceeds the carbide contraction, so that the net result is an expansion. In steels having more than about 1 per cent carbon, the carbide contraction exceeds the allotropic expansion, so that the net result is a contraction. The way in which these two factors vary with carbon content is shown in Fig. 7, in which graph *A* represents the effect of carbon percentage on the allotropic expansion, and graph *B* or *C* represents the effect of carbon percentage on the carbide contraction.

The work of the above-mentioned investigation has shown that, by rapidly cooling steels from above the critical range, it is possible to suppress entirely the carbide contraction, while permitting the gamma-to-alpha expansion to take place. This results in a "martensitic" structure. These experiments would indicate that the gamma-to-alpha expansion in the steels investigated is much more rapid than the carbide contraction. For this reason it is necessary to modify somewhat any conclusions that may be reached by study of space lattice relations alone. Even when the space lattice

[6]H. DeNolly and L. Veyret, "Note on the Transformation of Steels," *J. Iron & Steel Inst.*, 1914, No. 2, p. 165.

[7]Andrew, Rippon, Miller and Wragg, "The Effect of Initial Temperature Upon the Physical Properties of Steel," *J. Iron and Steel Inst.*, 1920, No. 1, p. 527.

grouping is such that no atomic migration is necessary for the formation of cementite on cooling, the change from potential to actual cementite is relatively so slow that it can be prevented without prevention of the change from gamma to alpha iron. With the possible exception of hyper-eutectoid steels of the higher carbon content, therefore, quenched steels may contain alpha iron and at the same time be free from actual cementite.

Hyper-Eutectoid Troostite

The above-described investigations of volume changes did not include carbon steels having more than about 1.2 per cent carbon. In the discussion of the space lattice relations of austenite it was shown that in the cooling of hyper-eutectoid austenites of the higher carbon percentages, unit cubes of alpha iron could probably not be formed without migration of iron atoms. The time required for this migration might, therefore, be expected to slow down the allotropic expansion so that it would be preceded and accompanied by the carbide contraction. The fact that in such steels the carbide contraction considerably exceeds in volume the allotropic expansion would probably make it more difficult to suppress this contraction while permitting the allotropic expansion to take place.

Even if by rapid cooling the carbide change in hyper-eutectoid steels can be prevented without preventing the allotropic change, there must be some intermediate rate of cooling such that the carbide contraction and allotropic expansion will take place simultaneously. The writer, by quenching hyper-eutectoid steels of the higher carbon content in oil at 300 to 400 deg. F. (150 to 200 deg. C.) has obtained structures, apparently "martensitic," in which the carbide and allotropic changes have occurred simultaneously. By quenching hyper-eutectoid steels at suitable rates, therefore, as well as by tempering hyper-eutectoid austenitic alloy steels, "martensitic" structures are obtained. According to the authors' definition of martensite, these so-called "dark etching martensites" should be renamed "hyper-eutectoid troostite."

Probable Condition of Carbon in Martensite

A study of the volume relations of cementite, alpha iron and gamma iron throws some light on the condition of the carbon in martensite. Though the space lattice arrangement of cementite is not known, the approximate relation between the volumes occupied by the same number of atoms of cementite, alpha iron and gamma iron can be calculated. The specific gravity of cementite, according to Benedicks, is 7.74 in steels having less than 1.26 per cent carbon. The specific gravity of pure iron, according to the same authority, is 7.87. If cementite had the same space lattice as alpha iron, its specific gravity would be about $\left(\frac{180}{224}\right.$ times that of alpha iron$\left.\right)$ 6.22. Since the specific gravity of cementite in steel having less than 1.26 per cent carbon is 7.74, the volume occupied by the same number of atoms in cementite is only 87.3 per cent that of alpha iron. The contraction of volume if iron carbide changed from the alpha iron space lattice to that of cementite would, therefore, be about 12.7 per cent.

In Fig. 7 the ordinates of the line *D* represent the percentage changes of volume that would occur if all the iron carbide in steel changed from the alpha iron space lattice to that of cementite. The ordinates of the line *E* represent the volume changes that would occur if all the carbide in steel changed from the gamma iron space lattice to that of cementite. Lines *A* and *E* are both drawn on the assumption that the allotropic volume change in pure iron, if it could be measured at room temperature, would be practically the same (1.2 per cent) as the actual measurements that have been made at the transition temperature. Since the volume-temperature curves of gamma and alpha iron probably separate somewhat as the temperature falls, the allotropic change of volume if measured at room temperature may be somewhat greater than 1.2 per cent. Any change in the position of line *E* on this account, would, however, be relatively slight.

In graph *B*, plotted from data on carbon steels in the article by McCance[6] previously referred to, the ordinates represent the maximum carbide contractions measured at room temperature. In graph *C*, plotted from

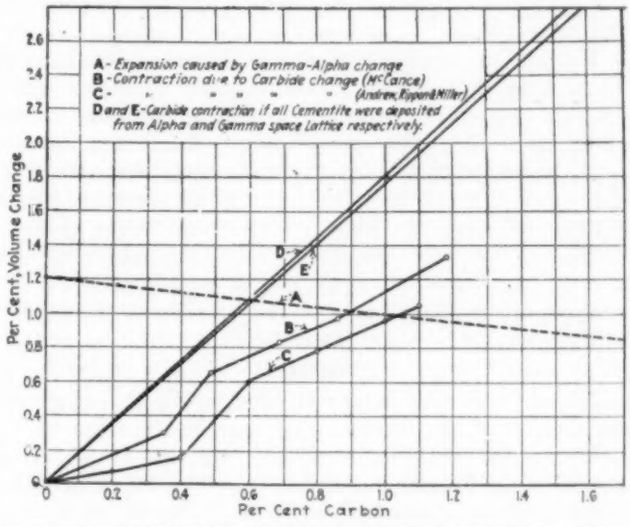


FIG. 7. VOLUME CHANGES IN STEEL DUE TO ALLOTROPIC TRANSFORMATION AND CEMENTITE FORMATION

data in the article by Andrew, Rippon and Miller[5] previously referred to, the ordinates represent the maximum carbide contractions measured within the temperature range in which they occur. Allowing for experimental errors, the agreement between these two series of measurements is very good. A curve drawn half way between curves *B* and *C* would, therefore, probably represent correctly the carbide contraction as influenced by carbon percentage.

Comparison of graphs *B* and *C* with lines *D* and *E* of Fig. 7 shows that the carbide contraction is a little more than half what it would be if the carbide change were from either the gamma or alpha space lattice volume to that of cementite. It is evident, therefore, that neither in austenite nor in martensite does the space lattice of the carbides correspond to that of either gamma or alpha iron. The iron atoms surrounding every carbon atom in austenite must be more closely packed than the iron atoms that are not in the immediate sphere of influence of a carbon atom. When the steel is so quickly cooled that the carbide change but not the allotropic change is suppressed, the volume occupied by every carbide group remains practically unchanged. This would seem to indicate that in martensite every carbon atom with its surrounding iron atoms

preserves essentially the same space lattice arrangement that existed in austenite. These carbide groups, though they are in a denser space lattice than the average space lattice of austenite, will be designated "austenitic carbide" groups.

It seems probable that in austenite every carbon atom holds its twelve neighboring iron atoms at a radial distance that is smaller than it would be if the carbon atom were replaced by an iron atom. Such a shortening of the radial distance need be relatively slight to account for the difference between the ordinates of graph *E* and those of graph *B* or graph *C* of Fig. 7. In martensite the density, and probably the arrangement, of an austenitic carbide group is practically the same as in austenite.

When opportunity is given for two austenitic carbide groups to come in contact (forming potential cementite) and to undergo the necessary great contraction of volume, actual cementite is formed. In order of increasing coarseness of the cementite particles, the resulting microstructures are known as troostite, sorbite or pearlite respectively.

Martensite, therefore, probably consists of alpha iron with austenitic carbide in suspension. It is not quite correct to say that the carbon is in solution in the alpha iron, since that would imply that every carbon atom in martensite takes the place of an iron atom in the alpha iron space lattice (in which every atom is surrounded by only eight other equidistant atoms). Such a loose arrangement of the austenitic carbide groups would not be likely to exist, since it would be opposed by the tendency of the austenitic carbide groups to undergo "carbide contraction."

SUMMARY

(*a*) Jeffries and Archer's conclusions in regard to the causes of the hardness of martensite seem to be confirmed by results of experiments at the U. S. Naval Engineering Experiment Station on the effect of temperature on the grain coalescence tendency of ingot iron.

(*b*) If the term "martensite" is to be limited so as to apply only to the constituent of steels in which the allotropic expansion but not the carbide contraction has occurred, the constituents, usually designated "martensite," of some hyper-eutectoid steels should be known as "hyper-eutectoid troostite."

(*c*) Martensite consists of alpha iron with "austenitic carbide" in suspension. In troostite, the austenitic carbide has undergone the "carbide contraction" to form cementite particles of the smallest size that can exist independently.

Production Costs in Belgian Plate-Glass Industry

Acting Commercial Attaché Samuel H. Cross reports that in general wages in Belgian plate-glass plants approximate four times the pay received by employees in this industry in 1914. It is estimated that the production costs now have reached 600 per cent of those prevailing before the war. This advance is due not only to the increase in raw material costs and wages but also to the introduction of the 8-hr. day. This has necessitated the use of three shifts per day instead of two, which was the pre-war practice.

It is estimated that in the total production cost labor enters for 16 per cent, coal for 21 per cent, raw materials for 47 per cent and maintenance 10 per cent. The estimated cost of sales, agencies, warehousing and travel amounts to 4 f. per sq.m.

Spectroscopic Examination of Converter Flame*

BY W. J. CAMPBELL

The spectroscope is more extensively used on the Continent than in this country for the examination of converter flames. The usual practice here is to take the blow completely down, thus eliminating practically all the carbon, and thereafter to recarbonize with suitable fluid metal additions. In many Belgian and Swedish foundries engaged in the production of small steel castings the blow is brought down before the flame has completely dropped. Without any additions of recarbonizers the molten metal may contain 0.40 to 0.60 per cent carbon. The usual additions are added molten. The resultant steel is extremely hot and fluid, and is shanked from the converter in hot crucibles. The amount of short-run castings and skulls is considerably lower than with the usual procedure of completing the blow and either casting low-carbon steel or adding high-carbon metals.

The spectroscope is useful for indicating the point at which to bring down the blow in the second method of working. Many attempts have been made to obtain higher carbon steel by this method without the use of a spectroscope, but the great uncertainty and the erratic results secured condemned the practice. With the aid of the spectroscope better and more regular results may be obtained, but the process is still not so accurate as the practice of completely blowing and recarbonizing for obtaining a pre-arranged carbon content to within, say, a few points. The spectroscope is not so essential for judging the finish of the blow as for examining the carbon flame before the whole of the carbon has been completely burnt off.

At the beginning of the blow the spectrum is continuous and indefinite. With the faint appearance of the flame the characteristic yellow line of sodium is seen. For a short period this line is very faint and appears in flashes. As the flame gradually increases and becomes steady, the sodium line becomes stationary and brighter. As the flame and temperature rise the spectrum lines become more complex. The line spectrum of thallium and lithium and the banded spectrum of many other metals may be observed, but they are not of any particular value for the control of the blow. The principal lines to be noted are the carbon lines, which appear bright green. They are faint at first, but gradually, as the flame rises, they become brighter and more distinct, until, with the falling of the carbon flame, they diminish in number and fade completely away with the final drop of the flame.

The advantage for many classes of small foundry work of obtaining very hot and fluid steel may well repay the cost of installing a spectroscope.

The following table gives a brief outline of an average blow and its spectroscopic examination.

Duration of Blow	Eye Observation	Spectroscope Observation
3 min.....	Sparks, but no flame....	Faint flashes of sodium line in continuous spectrum.
3 to 10 min....	Flame gradually appearing at mouth of vessel and increasing.....	Yellow sodium line becoming stationary and bright. Also lines of thallium and lithium and bright green carbon lines.
10 to 12 min...	Flame brighter and longer and temperature rising.....	All the above lines fixed and brighter, the carbon lines being especially clear.
12 to 14 min...	Flame at maximum height and brightness.	Addition of green carbon lines in blue and green. All lines at their maximum brightness.
14 min. to completion of blow.....	Flame falling gradually.	Carbon lines not so luminous and gradually fading with dropping flame and eventually disappearing with the end of the blow.

**The Engineer*, Aug. 5, 1921]

Glimpses of Ohio Ceramic Industries—II

Crooksville China Co., Located at Crooksville in Southern Ohio, Manufactures Tableware by Employment of Technical Methods—Preparing the Slip—Materials for Pottery Bodies—Scientific Study of Clay Body Composition—Alkali Treatment of Casting Slip—Constitution of Glazes*

BY CHESTER H. JONES

LOCATED at Crooksville, in the same southern Ohio district, near the previously described plant, the Crooksville China Co. is engaged in the manufacture of medium grades of china- and dinner-ware, employing to a large extent the American clays as raw material, although some items are imported.

SAGGERS

Recent investigations of the American Ceramic Society have shown that the nature of the sagger, or burned clay box, holding the ware during burning is a most important consideration for any process where the pieces must be protected from mechanical action in the kiln. All saggers employed at this plant are hand-molded from raw materials, one-third of which is native Ohio clay, the remainder coming from other clay fields of America, excepting a small quantity which is imported. The stoneware clays mined in this district make excellent saggers. Hand-molding assures a more uniform consistency or temper to the finished sagger without the chance for laminations so common to machine-pressed saggers. Drying is accomplished by placing saggers on shelves located over a brick gas flue from the kilns. They are subsequently glazed and burned.

PREPARING THE SLIP

Materials used in the manufacture of the china are North Carolina china clay, Florida china clay, English ball clay, English china clay, feldspar and flint. These are delivered from the railroad cars to bins, from which they are drawn to an industrial hopper car on narrow-gage track running along the front of the row of bins. Definite quantities are weighed into the car by placing it over track scales. Each charge weighs about 1,400 lb. and fourteen charges are made each day. The car is emptied to the blungers, or vertical steel tanks equipped with agitating paddles, where, mixing with water, the creamy solution or slip is beaten to a uniform consistency. All the clay-working machinery in this factory is made by the Patterson Foundry & Machine Co.

MATERIALS FOR POTTERY BODIES

In general the preparation of white ware bodies or porcelains involves the use of clay, flint and fluxes. Either kaolin or china clay, or both, may be used, and ball clay may be employed, as in this instance. The kaolin may be either English or domestic, fineness of grain being the main distinction between the two. The English kaolin works up to a finer slip. Ball clays add to the strength and vitrification properties of the ware. Neither the English nor German potteries use ball clay, but substitute a plastic kaolin.

The added flint is silica, and ground sand is substituted for flint in the United States. Rock quartz is sometimes used instead of flint, although it is costly to grind. Silica from southern Illinois has recently been considered a promising material for pottery bodies. True flint is a pebble gathered on the coast of France having an average egg size and a dark gray to white color. It is exported to the United States and calcined in rotary kilns. This operation burns out the organic material, causing the pebbles to soften and turn to a whiter color. These pebbles are subsequently crushed in a chaser mill and ground in ball mills using raw flint pebbles for a pulverizing medium.

There is less of this material on the market each year. It can be distinguished from ground sand only by the aid of the polarizing microscope, for there is chemically no difference between the flint and sand; possibly the sand is purer. Flint, being formed in the chalk cliffs of the English Channel, contains more lime. Sand is prepared by grinding in ball or tube mills.

FLUXES

Fluxes are often added to assist vitrification. Lime may be added as $CaCO_3$ in amounts up to 2 per cent to make the feldspar active. In Holland 30 per cent of lime is introduced and the ware is burned at a low heat. This gives a very porous body, which takes a high tin oxide glaze and is known on the market as Delft ware.

Other fluxes in use are magnesia, light and heavy, steatite or soapstone, and feldspar. Of all these feldspar is the most important and a good commercial grade will have the following analysis:

	Per Cent		Per Cent
Al_2O_3	16.76	K_2O	9.80
SiO_2	69 45	Na_2O	2.60

Potash feldspar contains about equal amounts of soda and potash. It is a white mineral occurring in dikes in Maine, Connecticut, New York, Pennsylvania, Virginia and the Southern States. It is quarried, hand-picked and ground in ball mills. Soda spar is about the same grade of material, but is a softer mineral. Lime spar is not used by the potter. Of the market grades, No. 1 spar is carefully selected hand-picked material, while No. 2 is the standard grade, having an Fe_2O_3 content less than 0.20 per cent.

FLUXING ACTION OF FELDSPAR

Below cone 0.05 feldspar acts as a grog, but at higher temperatures is a neutral flux behaving in a steady and uniform manner. It is frequently spoken of in burning operations as a solvent, since it performs on the other

*For Part I see CHEM. & MET. ENG., vol. 25, No. 12, p. 562, Sept. 21, 1921.

constituents like water on sugar. From 19 to 20 per cent is needed in a body mixture to get complete vitrification of the mass. It exerts a marked positive effect on the translucency of the ware. In the kiln it lowers the coefficient of expansion of the mixture to a small but important extent to prevent crazing or cracking of the glaze.

Cornish stone is similar to feldspar, but harder. It contains more silica, less alkali and less iron. It also has a fluorspar content. English potters use it mainly from tradition and habit, for it is without particular commercial value at the present time.

Scientific Study of Body Composition

The clay-working business, particularly the pottery industry, has been a mystery to the layman mainly because he has been unable to see how the particles of a body form. Old-time potters have taken advantage of this, claiming to have special knowledge handed down on the death bed from father to son. They claim that new grinding methods do not give the same size and shape of particle as their own crude traditional processes of size reduction. As a matter of fact, the method is immaterial so long as uniformity of particle size is secured to give strength to the mass. Material which is too fine may cause dunting.

Ceramists and physical chemists have among other things found that the study of bodies by triaxial diagrams has done much to dispel the mystery surrounding body mixtures. The slow accumulation of such diagrams in scientific publications as worked out by the various investigators for all sorts of possible body materials is going far toward putting the pottery industry on a scientific basis. It is upon such industrial research that the future progress of the ceramic industries depends.

Obtaining the Plastic Material

After the proper constituents have been thoroughly blunged at the Crooksville plant the slip is drawn into the lawns, which are revolving cylindrical frames covered with bolting cloth, each lawn consisting of two concentric cylinders, so that the material is screened twice. This operation rejects all the coarse material in the slurry or slip. Double-piston pumps acting at 100-lb. pressure convey this slip from the agitated slip cistern below the lawns to the three plate-type filter presses. The water from these presses is stored and eventually returned to the blungers for the production of subsequent slip.

The smooth putty-like cake from the filter presses is thrown into a pug mill (English type, Windsor), whence it is extruded. Cake as it comes from the filter presses contains about 25 per cent water, which is not uniformly distributed. The pug mill, which consists essentially of a closed screw conveyor, extrudes an evenly tempered product.

Alkali Treatment

Pugged clay is transferred to the first of a pair of casting slip mills operating in series. They are simply tanks of concrete and steel, equipped with agitating mechanisms like the blungers previously mentioned. The material enters the first and after a time is allowed to flow to the second one, located at a lower level. Each slip mill charge consists of 1,000 lb. of pugged clay, six buckets of water, 20 oz. of soda ash and 10 oz. silicate of soda, the two latter being mixed with the water. After a thorough blunging in the slip mills the product is pumped to the upper floors.

The purpose of alkali treatment of clays for purification and use in the casting process is well outlined in Technologic Paper 51, U. S. Bureau of Standards, by A. V. Bleininger. Alkalis tend to hold the clay in suspension in a fine-grained and jelly-like mass or state of deflocculation. The viscosity of the clay-water system is caused to change so that a constant degree of fluidity can be maintained by the use of the sodium salts added. Opposite effect or precipitation can be had by using acid electrolytes.

The casting process used in producing cup handles and irregular pieces such as vegetable dishes, pitchers, etc., consists of pouring this thick water suspension or slip from the mills into plaster of paris molds of the desired shape. The porous plaster begins at once to absorb the water from the slip and a coating of the clay body forms on the surface of the mold. When the desired thickness of ware is obtained, the remaining slip is poured off, leaving an article of the required shape.

With partial drying the body then stiffens and shrinks away from the mold, permitting the removal of the piece for complete drying. If the casting slip were made up with pure water, the resulting shrinkage would be very high, causing damage to the shape. The addition of the sodium carbonate and silicate reduces the amount of water required to form the solution, and consequently the drying shrinkage is lessened. Furthermore, a settling of the slip previous to the casting of the piece causes larger particles to precipitate from the solution.

The above-mentioned bulletin describes tests which show that the washing of kaolinitic clays may be decidedly improved as far as the quality of product is concerned by adding caustic soda or soda ash and sodium silicate in definite small amounts in the blunger. It makes possible more complete sedimentation of the undesirable granular impurities, improves the color of most clays where whiteness is desired, enriches the content in the clay substance, decreases drying shrinkage and tends to increase burning shrinkage. Clays containing iron as finely divided ferric oxide cannot be successfully treated by this process. Sodium hydroxide is absorbed to a far greater extent than the carbonate and probably combines chemically with the clay.

Preparation of Glazes

The large part of the product of this factory involves the use of a white glaze in which the ware is dipped and subsequently burned. Materials used include feldspar, zinc oxide, white lead, whiting, paris white (lime), and china clay. Frit, or artificial glassy ingredients, previously prepared is added to and ground with these materials. This frit is prepared by mixing boric acid, borax and flint, pouring the mixture into a sagger and burning to a glass in the kiln. On cooling it is broken up for mixing with other glaze substances.

The ingredients of the glaze are mixed wet and ground in three Patterson pebble mills, each containing 1,000 lb. of pebbles. After a thoroughly ground mixture is obtained it is drawn through lawns to remove grit and dirt and is then ready for the dipping room. Other equipment in the glaze room is a pebble mill and vertical cylinder mill for preparing sagger glazes. The

saggers are glazed to prevent pieces from chipping off and falling on the ware to its damage while in the bisque kiln.

Calculation of Glazes

Potter's or trade recipes for glazes are usually expressed in the form of batch weights and have been evolved in the past from practical experiments after the manner of cooks rather than ceramists. These formulas have "just happened" after generations of rule-of-thumb ceramics, which is no guarantee that they are the best possible mixtures. Our leading ceramic schools, on the other hand, have attacked the glaze problem in a scientific manner and in the compounding of both glazes and bodies now employ methods of calculation which might be called ceramic stoichiometry. Empirical formulas are used to express the compositions of materials and mixtures. They show in a way the actual chemical composition, since they contain the relative molecular proportions of the various oxides. They do not, however, attempt to represent the actual chemical or mineralogical constitution. This is simply another step forward in the analysis for the chemical control of the ceramic industry.

Seger was the first to adapt this stoichiometric method of mineralogists to ceramic work, and ceramic chemists almost without exception now use it. In a lecture course at Illinois University, Cullen W. Parmelee explains the procedure of calculations as outlined in the following paragraphs:

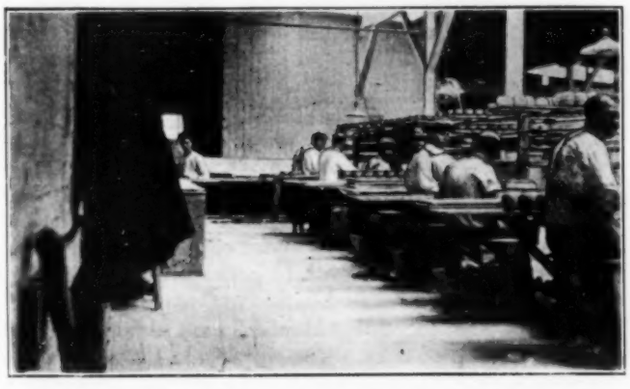


FIG. 7. ATTACHING HANDLES TO CUP BODIES

"In the construction of the formula the oxides of the mono- and bi-valent metals, which form bases and act as such in silicate fusions, are grouped under a general heading, RO. These include the alkalis, alkaline earths and most of the coloring oxides, CuO, CoO, FeO, MnO, etc. The oxides of the trivalent metals are generally grouped with the Al_2O_3 which is almost always present. Alumina plays a double rôle in that it may act as a base or as an acid, depending upon the conditions. The R_2O_3 group is often referred to as the intermediary group in glaze compositions. Silica (SiO_2) is the principal oxide of the acid group. In some cases it may be partly replaced by other acid oxides, but it is generally present in considerable amounts. Ceramic products may be generally considered as silicates, or silicate mixtures.

"The ceramic formula representing a mineral ingredient, a body, a glass or a glaze may be expressed in the general form $x\text{RO}.y\text{Al}_2\text{O}_3.z\text{SiO}_2$ where x, y and z are numerical coefficients indicating the number of molecular parts of each group present. In clays and many of the minerals used as ceramic materials the proportion of basic oxides is very small and it is found of advantage to make the coefficient of Al_2O_3 equal 1. This has been adopted as a custom and the mineral or body formula is expressed as $x\text{RO}.\text{Al}_2\text{O}_3.y\text{SiO}_2$. Thus orthoclase has the formula $K_2O.Al_2O_3.6SiO_2$, and kaolinite is expressed as $Al_2O_3.2SiO_2.2H_2O$.

"In glasses, glazes and enamels the Al_2O_3 has a wide variation and frequently is absent. The RO oxides here play an important part, and the custom has been adopted of making RO equal 1 and giving to the Al_2O_3 and SiO_2 suitable coefficients to represent their relative molecular proportion. The general glaze formula is, then, $\text{RO}.y\text{Al}_2\text{O}_3.z\text{SiO}_2$. It is to be remembered that RO represents the sum of the oxides and their individual molecular proportions are such that the sum equals 1.

"In glasses, glazes and enamels the Al_2O_3 may vary widely and is frequently absent, while the oxides of the mono- and bi-valent metals may be varied and substituted, but are always present. As a matter of convenience in comparison of formulas it has become the custom in the case of glasses, glazes, etc., to use such minor numerical coefficients to express the molecular proportion of the various oxides as to make the sums of the basic or RO members equal to unity. The general formula in this case becomes $\text{RO}.y\text{Al}_2\text{O}_3.z\text{SiO}_2$. The composition of a porcelain glaze is expressed as

$$\left.\begin{matrix}0.3\text{K}_2\text{O}\\0.7\text{CaO}\end{matrix}\right\}\ 0.5\text{Al}_2\text{O}_3\ \ 4.0\text{SiO}_2$$

or a stoneware glaze as

$$\left.\begin{matrix}0.3\text{K}_2\text{O}\\0.2\text{CaO}\\0.1\text{MgO}\\0.4\text{ZnO}\end{matrix}\right\}\ 0.5\text{Al}_2\text{O}_3\ \ 3.0\text{SiO}_2$$

These formulas must not be confused with the chemical formula of a compound. They merely express in a convenient way the proportions of various oxides present, although they are not introduced as such, nor do they exist in definitely known compounds in the glaze."

Shaping the Bodies

Plates, the bodies of cups and similar regular pieces are thrown on the jigger, while cup handles and irregular pieces as previously described are slip castings. Fig. 7 shows a group of workmen attaching handles to cup bodies, the plaster of paris slip-casting molds for handles appearing in a row on the bench in the background. The clay is slightly wetted at the points of contact between handle and cup, causing the two clay parts to weld to form one piece. This work is carried on very rapidly on piecework basis, as are most of the other operations in the plant.

The jigger or jolly is essentially a potter's wheel revolving in a horizontal plane with a plaster of paris mold conforming to the outside shape of the piece mounted thereon. The inside shape is obtained by throwing down a steel cutting tool to a set position after the machine starts to revolve. Ordinarily three operators work at each large jigger. The "batter out" throws a lump of plastic body clay of approximately the desired amount upon the adjacent table and flattens it out to approximate thickness and shape by striking with a flat paddle or iron block with a handle. The jigger-man seizes it, throws it into the jigger and pulls down the hinged cutting tool to position, trimming out the

surplus clay. He then removes it to a table on the opposite side, where irregularities are wiped off with a wet cloth or brush by the third operator. Finally it is laid upon a movable rack or tray. All clay is transferred to the jiggers by elevators and overhead trams with traveling platforms.

Drying

The racks containing the finished shapes are transferred by hand to the driers. The drying chambers consist of rooms divided off by wooden partitions with steam pipes passing around the sides. From five to six hours are consumed in drying the ware. This time is sufficient because of the thin walls common to chinaware objects.

Burning

The dried pieces are conveyed to the kiln room, where they receive the bisque burn. The kiln room equipment consists of four bisque kilns, five gloss or glaze kilns and eight decorating kilns. Natural gas at 45c. per 1,000 cu.ft. is employed for fuel. Fig. 8 shows a corner

FIG. 8. VIEW OF KILN ROOM

of the kiln room with saggers stacked in the background and the entrance to one of the bisque kilns on the right. The bench in the right foreground with plates and saggers stacked on the shelves is employed in loading the ware in the saggers. To prevent sticking pieces are separated in the sagger by resting each on small triangular section clay supports imbedded in the sagger wall at an angle so that the contact where the piece rests is a sharp point of clay material. In this way the small protuberance of clay sticking to the piece after the burn may be broken off by a sharp blow in the chipping room.

Glazing

The saggers are stacked in the kiln in such a manner that those containing large pieces are in the center and the smaller ware near the outside of the circular kiln. Firing time in the bisque kilns ranges from forty-eight to fifty hours and a temperature of cone 8 is attained. After this treatment the ware is removed to the dipping department, where the glaze is applied by simply dipping each piece in a tub of the glaze solution, the preparation of which has been described. It is then returned to the glaze kilns, where it is fired from twenty to twenty-six hours at a maximum temperature of cone 4. Cones are used in regulating the bisque and gloss kilns, while the veritas disk is employed in the decorating kilns.

Decorating

After chipping off the supports previously mentioned, the pieces are transported to the decorating department. Here either transfer method or hand-painting is employed in putting on decorative designs. In the transfer process the portion to be decorated is first treated with a coat of ordinary shellac brushed on as a binder for holding transfer paper in place. The designs are printed on the decalcomania paper with special inks. This paper is purchased from the manufacturer in strips and sheets of varying shapes to fit the piece and is covered with numberless different designs. Rubber stamps with special inks and stamp pads are also used in some cases. Hand painting is employed chiefly in decorating cup handles and edges. Fig. 9 shows the interior of a decorating kiln with the dishes stacked on knock-down shelves. Eight hours is required to burn on the decorations and a temperature of about cone 0.015 is reached. This is sufficient thoroughly to penetrate the glaze with the colors. The shellac binder and paper are entirely volatilized and the finished pieces are finally removed from this last process. The wholesale price of chinaware is largely determined by the method and type of decoration.

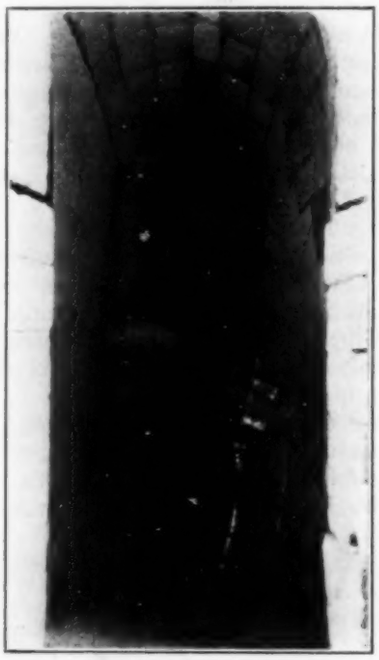


FIG. 9. INTERIOR OF A DECORATING KILN

The summation of impressions after a walk through this plant leaves with the observer the thought that the manufacture of tableware is a nice business. The factory is spotlessly clean, light and well ventilated, giving ideal conditions for the employees and reflecting good cheer in the personnel of the operating staff.

Zinc in the First Half of 1921

The Geological Survey reports that the smelter production of zinc from foreign and domestic ores for the first six months of 1921 totaled 102,525 tons, as compared with 258,108 tons in the same months of 1920 and 205,269 tons in the last half of 1920. The stock of zinc held at smelters and in warehouses June 30, 1921, was 94,747 tons, compared with 71,037 tons at the end of 1920 and 29,892 tons one year ago. The apparent domestic consumption of zinc, taking into account imports and exports, amounted to 83,965 tons in the first half of 1921.

The number of retorts in operation on June 30, 1921, was 36,000, compared with 56,000 at the end of 1920 and 75,000 on June 30, 1920.

Synopsis of Recent Chemical & Metallurgical Literature

Elastic Limit—Prof. William Dalby, in a paper read before the Engineering Conferences of the Institution of Civil Engineers, June, 1921, notes that the limit of proportionality between stress and strain during tension loading has often been called the elastic limit, but such a term conveys the idea that the elastic power of the material is exhausted, which is by no means true. Metal possesses elastic properties right up to the instant of fracture.

The author has devised an optical automatic recorder of great sensitivity and precision, and finds that if a bar strained beyond the limit of proportionality be unloaded, the piece will spring back and to all appearances acts like a perfect spring. Investigation shows, however, that no part of the stress-strain curve on unloading or reloading is a straight line. In fact such procedure always draws loops

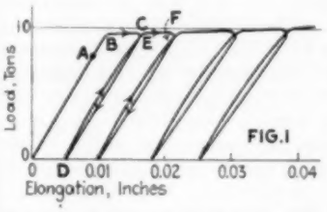


FIG. 1

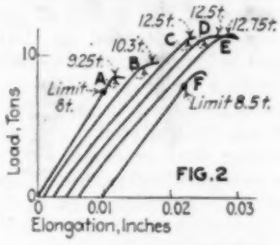


FIG. 2

like Fig. 1, the areas increase on subsequent reloadings at first rapidly in some materials, tending to a limiting value.[1]

From a practical point of view, therefore, the term elastic limit should mean the limit where proportional elasticity ends and unproportional elasticity begins. Proportional elasticity is destroyed by overstrain; in alloy steels it remains so, as shown in the successive curves in Fig. 2. Iron and soft steels tend to recover their property of proportional elasticity by mere lapse of time—very short on moderate tempering, merely boiling in water. Alloy steels and high-carbon steels recover only after a high anneal (550 deg. C. for 1 hour for the last curve of Fig. 2).

Dr. Rosenhain observed that both the "limit of proportionality" and the "limit of restitution" depended upon the accuracy of measurement. It is impossible to determine the former by noting whether or not a loop was formed on successive loads, since there is always a certain thermal effect due to elastic stretching; in some cases a rise of temperature, in some a slight fall. If one allowed time for that temperature difference to vanish, the energy was changed, and when the load was taken off, a loop in the stress-strain diagram was bound to occur.

The heat generated in slow stretching of a piece of metal is always less than the mechanical work done, on account of the internal changes produced. The difference varied widely with different metals. In iron particularly, the amount of heat generated is very nearly the whole of the work done; therefore a very small loop (indicating internal work) would result. In copper the loop would be large; in aluminum larger still; the size varies inversely with the melting point and the latent heat of fusion.

Absorption of Nitrogen Oxide by Sulphuric Acid.—The analysis of higher nitrogen oxides requires that they shall first be absorbed by sulphuric acid. The transformations which they undergo during this absorption has led to many interpretations. Thus some authors, especially those who use physical methods, admit the direct passage from NO into NO_2, whereas those using chemical methods have noted in some cases the presence of N_2O_3. This contradiction has been solved by Wourtzel (*Comptes rendus*, vol. 170, 1920, p. 109) who has shown that there is no total decomposition of N_2O_3 into $NO + NO_2$ and that NO can combine only partly with NO_2 to give N_2O_3, so that amounts of N_2O_3 up to 6 per cent can exist under atmospheric pressure. This small quantity, due to its great aptitude to react and to be regenerated rapidly at the expense of NO and NO_2, causes the formation of nitrous derivatives in the presence of absorbing reagents. This explanation is more satisfactory than that of Lunge, who stated that NO_2 and NO in the presence of H_2SO_4 would result in the reactions

$$2NO_2 + H_2SO_4 = 3HNO_2 + HNOSO_4$$
$$2NO + HNO_3 + 3H_2SO_4 = 3HNOSO_4 + 2H_2O$$

A. Sanfourche has made a series of tests to determine whether the reactions as indicated by Lunge take place (*Comptes rendus*, vol. 172, June 20, 1921, p. 1573.) He has found that when nitrous gases whose total composition approaches N_2O_3 react with sulphuric acid they do not behave as would a simple mixture of NO and NO_2. He concluded that the reactions taking place are

$$NO + NO_2 = N_2O_3$$
$$N_2O_3 + 2H_2SO_4 = 3HNOSO_4 + H_2O$$

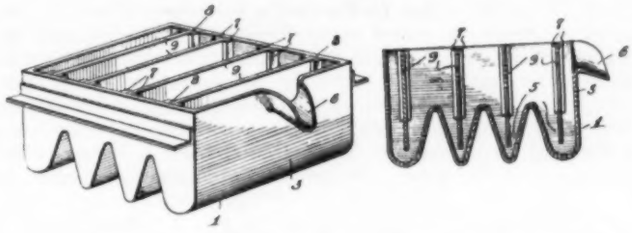
[1] "Researches on the Elastic Properties and the Plastic Extension of Metals," *Phil. Trans.*, Series A, vol. 221 (1920).

Recent Chemical & Metallurgical Patents

American Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

New Type of Cascade Pan.—Ludwig A. Thiele, of Columbus, Ohio, has patented a new cascade pan of the type which is usually employed in the concentration of sulphuric acid. The pan has an open top, vertical side walls and a deeply corrugated bottom. As will be noted in the accompanying diagrams, there are a number of baffle plates in each pan which are so fixed that the acid flowing through the pan is compelled to follow a tortuous path, and since it is exposed to the extended heating surfaces of the pan, rapid evaporation is thus effected. The pans



are so adapted that they can be assembled end to end in the cascade commonly used in concentration plants. The construction of the pan can be noted from the figure. The side wall 3 to the pan 1 are suspended in an intermediate position in the pockets 5 by the vertical ribs 7, which form sockets 8 for the baffle plates 9. (1,380,689; June 7, 1921.)

Separation of Borax From Potassium Salts.—Crude salts such as those obtained from Searles Lake, California, by concentration and cooling of the brine, are heated and the water they contain is sufficient to cause the borax to be redissolved. If the hot mixture then is spun in a centrifuge, the liquor containing the borax is effectually separated from the potassium salts, which can be further purified by spraying with a small amount of hot water. It is claimed that a very pure product can be obtained in this manner. (1,382,825; Clinton E. Dolbear, assignor to Industrial Research Co., of San Francisco, Cal., June 28, 1921.)

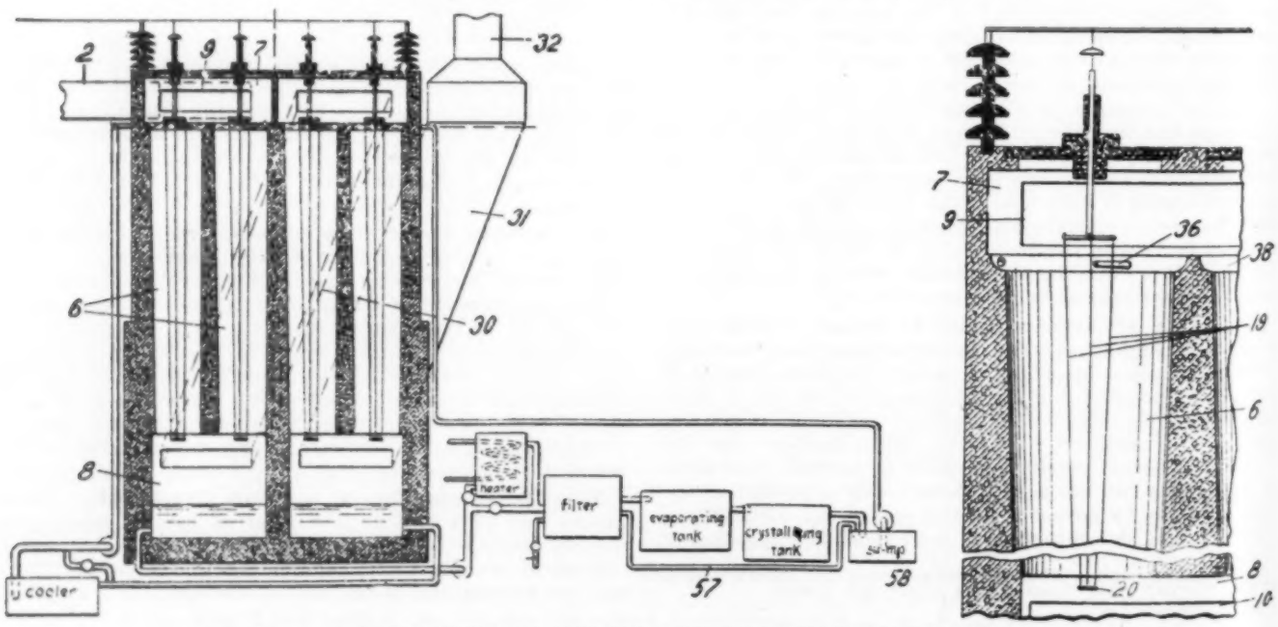
Manufacture and Uses of Selenium Oxychloride.—Victor Lenher has been granted a number of patents relating to various methods of preparing selenium oxychloride and a number of important uses for this article. In patent 1,382,920 the preparation is carried out by combining selenium

tetrachloride, which is a white crystalline solid, directly with selenium dioxide, also a white crystalline solid, to form the liquid selenium oxychloride. The product as it is formed acts as a solvent for the constituent materials and thereby facilitates the reaction. Carbon tetrachloride, chloroform or some similar solvent is also used. It is necessary that the process be carried out in a vessel which will not be attacked by the product, such, for example, as porcelain, terra cotta and glass or glass-lined equipment. Modified methods of preparation are outlined in patents 1,382,921 and 1,382,922. Selenium tetrachloride is formed by the action of chlorine and water on selenium. This compound, reacting in equi-molecular proportions with water, produces selenium oxychloride and hydrochloric acid; the latter is driven off by heat leaving the liquid selenium oxychloride. As in the previous patent, carbon tetrachloride is used as a solvent. Still another process of preparation is by means of a reaction between selenium dioxide and water, followed by dehydration with phosphorus pentoxide, calcium chloride or a similar dehydrating agent. Selenium oxychloride is claimed to possess remarkable solvent properties, being capable of dissolving many substances and compounds for which no known solvent has hitherto been discovered. Among the substances which it will dissolve are: Japans, paints, varnishes, rubber (pure or vulcanized), resins, pitch, glues, shellacs and lacquers, waxes, oils, fats, certain metals and oxides, salts and phenolic condensation products (including the infusible and so-called insoluble products). In patent 1,385,081 it is pointed out that selenium oxychloride is a solvent for the oxides of molybdenum, selenium, arsenic and vanadium, but that it will not dissolve the oxides of titanium, tungsten, zirconium, columbium and tantalum. Hence it is possible by this selective solvent action to separate various mixtures of the soluble and insoluble materials. Selenium oxychloride will react with various oils and greases to form waterproof, rubber-like compounds which may be used as rubber substitutes for certain purposes. (1,382,920, 1,382,921, 1,382,922, issued June 28, 1921, and 1,385,081, July 19, 1921.)

Recovery of Soluble Constituents From Furnace Fumes.—A process claimed to be an improvement on the usual methods for the electrical precipitation of fume or dust has been patented by Harry V. Welch, assignor to International Precipitation Co., of Los Angeles, Cal. It is proposed to supply water to the inside surfaces of the treater flues in order to carry away deposited material and to maintain smooth electrode surfaces. The water is used in a cyclic manner and is heated by waste heat from the furnaces. The operation of the process can perhaps be best understood by consulting the accompanying diagram.

The hot gases coming, for example, from a cement kiln or kilns, and carrying dust and fume containing potash as a constituent, are conducted through flue 2 to the upper header 7 of the first set of treater flues and passed downwardly through said treater flues into the lower header 8 and then up through the connecting flue 30 and down through the treater flues of the second set, in which they are discharged through flue 31 to the outlet 32. In passing down through the flues 6, the gases are subjected to the action of an electrical field produced between the discharge electrodes 19 and the inside surfaces of the flues 6. These surfaces are kept wet or flushed by streams of water flowing from the nozzles 36 and the body or sheet of water flowing in this manner on the inside surfaces of the flues. High tension current, either direct or alternating, is supplied for maintaining a sufficiently high potential difference between the discharge electrodes and the flues 6 constituting the collecting electrodes. The effect of the electrical field is to cause precipitation of suspended matter, including dust or fumes in the gases, on the body or sheet of liquid flowing down the walls of the flues, this precipitating action being especially effective when the electrodes are charged by a substantially unidirectional current produced, for example, in the manner set forth in the patent of F. G. Cottrell (No. 895,729, dated Aug. 11, 1908). By maintaining a continuously flowing stream of water on the inside of each treater flue, accumulation of any solid material on the walls of such flue is prevented, and a substantially smooth surface free from projections tending to develop discharge from the collecting electrodes is maintained irrespective of the nature of the material being precipitated. This is of especial advantage in precipitating dust or fume, such as cement kiln fume, containing a comparatively high proportion of potassium salts, which would otherwise tend to form a poorly conducting deposit, interfering seriously with precipitation. By thus maintaining the collecting electrodes in condition of maximum effectiveness, it is possible to increase the velocity of the precipitating action and correspondingly increase the rate of flow of gas through the apparatus, with the result that the dust precipitating capacity of a plant of given size is increased to a considerable extent. (1,382,037; June 21, 1921.)

Acid-Resisting Aluminum Alloy.—An alloy particularly suited for resisting the corrosion of nitric acid and nitrate derivatives, such as picric acid, is prepared from purified aluminum and lead in the following proportion: Aluminum, 89 to 94 per cent; lead, 5 to 10 per cent, and 1 to 2 per cent of some oxidizing material such as metallic magnesium. The finished alloy is said to be characterized by increased density and ability to withstand high pressure and corrosion. (1,385,223; Foster Milliken, of Lawrence, N. Y., assignor to Foster Milliken, S. Fullerton Weaver and James M. Replier, as trustees; July 19, 1921.)



APPARATUS FOR RECOVERY OF SOLUBLE CONSTITUENTS FROM FURNACE FUMES

Current Events

in the Chemical and Metallurgical Industries

Another Muscle Shoals Offer

Details of the offer of C. E. James, of Chattanooga, Tenn., to take over the Muscle Shoals water-power project and the nitrate plants have been given out by the War Department. The following constitutes the entire contents of two letters addressed by Mr. James to the Secretary of War:

First. I will pay for the general plants, land and material at Muscle Shoals, Sheffield, Ala., $5,000,000.

Second. For rent on Wilson Dam and Dam No. 3 I would pay the following amounts for 97-year lease:

$1.00 per annum average horsepower first year
1.50 per annum average horsepower second year
2.00 per annum average horsepower third year
2.50 per annum average horsepower fourth year
3.00 per annum average horsepower fifth year
3.50 per annum average horsepower sixth year
4.50 per annum average horsepower seventh year
5.50 per annum average horsepower eighth year
6.50 per annum average horsepower ninth year and thereafter

All taxes on Government property and equipment to be paid by the Government.

I would not ask the Government to guarantee any specified amount of power; I would want them to put in the electric equipment capable of producing 400,000 hp.

If the Government put in additional dams above Muscle Shoals in the Tennessee River to aid navigation all the way to Chattanooga to a boating stage of 9 ft., and 6 ft. Chattanooga to Knoxville, the horsepower would run to 800,000 at Muscle Shoals. If so, the Government would receive rental on 800,000 hp., the Government to have the right to equip the plant to 800,000 hp., if it decided to do so, I to take the increased power as produced at above rates.

The concrete foundations in dams ought to be made capable of installing a total of 800,000 hp. machinery, but only install 400,000 hp. now, Government to have, free, 300 hp. current to operate lock gates.

I would operate nitrate plants for fertliizers on a basis of 8 per cent profit, and keep in good condition Plant No. 2, subject to be turned over to the Government in case of emergency.

I would like to have the option, if my proposition is accepted, but not to be embodied in contract, the right to build a high dam for power and storage in the Clinch River at some point near Kingston, Tenn., so as to increase the flow of water at Muscle Shoals, and also to take care of loss of current on wire line, and make the electric current more regular between Muscle Shoals and Kingston, Tenn.

Ford's Muscle Shoals Plan Discussed

During a conference with engineers representing Henry Ford the Secretary of War requested that the Ford engineers and the Army engineers harmonize their views as to the amount of money necessary to complete the dam. He also called upon the Ford engineers for the details of their plan for converting Nitrate Plant No. 2 into a fertilizer factory. W. B. Mayo, of Mr. Ford's engineering staff, told the Washington correspondent of CHEMICAL & METALLURGICAL ENGINEERING that the conference was informal and preliminary and that, at the proper time, Mr. Ford will be glad to accept the invitation of Secretary Weeks to come to Washington.

To Study Light Alloys

As a result of a co-operative agreement entered into by the Bureau of Mines with a large manufacturer of scientific instruments, the bureau has been enabled to undertake a much more comprehensive investigation of the alloys used particularly in the manufacture of instruments of precision. The study is to cover a considerable number of the light alloys which are being or may be used for that purpose. The experiments will be conducted by R. J. Anderson at the Pittsburgh experiment station.

Industrial Relations Association to Meet in New York

The annual convention of the Industrial Relations Association of America will be held at the Waldorf-Astoria, Fifth Ave. and Thirty-fourth St., New York City, Nov. 1, 2, 3, 4 and 5. The following preliminary program is announced:

Tuesday, Nov. 1

1 p.m. Registration begins.
2 p.m. Round tables and sectional meetings.
5:45 p.m. Get-together dinner. Opening address, followed by five leading industrial representatives who will outline in ten-minute talks the most outstanding experiences in the industrial relations activities of their companies during the last year.

Wednesday, Nov. 2

10 a.m. Business conditions.
2 p.m. Sound employment practice.
2:30 p.m. Essential labor statistics and their uses.
3 p.m. Industrial relations department costs.
3:45 p.m. Round tables.

Thursday, Nov. 3

10 a.m. Determination of wage rates.
12:45 p.m. Luncheon meeting. Business session, I.R.A.A.
2:30 p.m. Unemployment.
4 p.m. Fundamental principles of human relations in industry.

Friday Nov. 4

Joint sessions with the Academy of Political Science in the City of New York, the general theme being "Constructive Experiment in Industrial Co-operation Between Employers and Employees."

Morning session at Town Hall. Personnel work and co-operation within industrial plants.

Afternoon session at Hotel Astor. Co-operation within separate industries.

Evening session and banquet at Hotel Astor.

Saturday, Nov. 5

Morning session at Hotel Astor. Industrial relations in governmental employment or departments and in financial institutions.

Afternoon session at Hotel Astor. Governmental and other organized counsel and information to promote better industrial relations.

American Mining Congress to Meet in Chicago

The twenty-fourth annual convention of the American Mining Congress will meet in Chicago, Oct. 17 to 22, with headquarters at the Congress Hotel. Special attention will be given to the following topics covering different phases of the mining industry: The railroads and the mining industry; co-operative effort and government regulation; standardization; the gold problem; increased use of metal products; taxation; the coal industry; national petroleum conference; educational conference; an American foreign mineral policy.

In conjunction with the convention, the National Exposition of Mines and Mining Equipment will be held at the Coliseum.

Superpower Report Almost Ready

The superpower report made under the direction of the U. S. Geological Survey now is in proof form and probably will be released for publication Oct. 1.

Portland Cement Output Increases in August

Production and shipments of portland cement in the United States continued to increase during August, 1921, and according to available statistics scored new high records for that month. The August production exceeded the average for August, 1917-1921, by about 15 per cent. Production for the first eight months of 1921 was about 99 per cent of the quantity produced during the corresponding period of 1920 and exceeded the average for the first eight months of 1917 to 1921 by about 8.5 per cent.

These statistics, prepared by Ernest F. Burchard, of the United States Geological Survey, and tabulated in the accompanying table, are based mainly on reports from producers of portland cement and in part on estimated data. They indicate that the present demand for cement is greater than might be expected in comparison with that for other mineral commodities, and that in the face of many handicaps to production supply is nearly keeping pace with demand at the height of the construction season.

CEMENT STATISTICS, 1921

Month	Production, Bbl.	Shipments, Bbl.	Stocks at End of Month Bbl.
January	4,098,000	2,539,000	10,300,000
February	4,379,000	3,331,000	11,400,000
March	6,763,000	6,221,000	12,000,000
April	8,651,000	7,919,000	12,600,000
May	9,281,000	9,488,000	12,450,000
June	9,296,000	10,577,000	11,150,000
July	9,568,000	10,301,000	10,414,000
August	10,244,000	12,340,000	8,280,000
	62,280,000	62,716,000	.....

To Use Chemical Agents in Alabama Tests

Tests with chemical agents will be made during the maneuvers that are expected to result in the sinking of the U.S.S. Alabama. Chemical bombs are to be tried out in the preliminary tests. Eight 50-lb. bombs charged with tear gas are to be dropped with the idea of gathering data as to the probable effectiveness of this type of bomb on a battleship. In similar manner, phosphorus and smoke bombs are to be dropped on the obsolete war vessel. One of the objects of the test is to determine the effect of smoke bombs in concealing the attack of aircraft and of the effect of white phosphorus clouds in neutralizing anti-aircraft elements.

The board of observers is to consist of three Air Service officers, two Chemical Warfare Service officers and two Ordnance officers.

In addition, there are to be night attacks, in which there will be demonstrated the tactical effectiveness of flares in illuminating a sea area under conditions simulating those of battle. The effect of white phosphorus in outlining seacraft at night is to be studied to determine if they can be outlined with sufficient distinctness to permit accurate attacks.

T.A.P.P.I. Notes

As noted in our last issue, the executive committee of the Technical Association of the Pulp and Paper Industry has voted to cancel the scheduled joint fall meeting of T.A.P.P.I. and the American Pulp and Paper Mill Superintendents Association. However, the committee on service to members of T.A.P.P.I., of which Fred C. Clark is chairman, is hopeful of obtaining for early publication in the trade periodicals all reports of committees and papers that would ordinarily have been presented at the joint fall meeting. As one of the steps in giving improved service to members, Mr. Clark's committee has issued a questionnaire which members are asked to check according to instructions, and return to the secretary's office without delay.

Reduction in Dues

The annual dues of active and associate members of T.A.P.P.I. will be reduced to $15. After voting unanimously in favor of this, the executive committee of the association instructed the secretary-treasurer to bill active and associate members for next year's dues at $15, instead of $25. This action was taken pending its ratification by the association at the next annual meeting, which, it is believed, will be unanimous.

U. S. Urged to Concentrate on Lighter-Than-Air Development

Based partly on the fact that the United States possesses helium resources, the National Advisory Committee for Aëronautics in a letter to the Secretary of the Navy urges that the United States undertake a more intensive development of lighter-than-air craft. In the letter Joseph S. Ames, chairman of the executive committee of the organization, points out that Germany persisted in her early efforts to develop Zeppelins and refused to be discouraged by failures, with the result that such airships served that country with effect in time of war. It is pointed out that the use of hydrogen in the ZR-2 was a contributing cause to the great loss of life. The fact that the United States possesses large helium resources is given as one of the reasons why lighter-than-air craft probably could be developed more successfully in America than in any other country.

Foreign Markets for Scientific Apparatus

American manufacturers who are desirous of engaging in the export trade will find considerable information of value in a publication of the Department of Commerce on foreign markets for scientific apparatus. It comprises contributions from our Consuls and Vice-Consuls in Argentina, Australia, Belgium, China, India, France, Egypt, Spain and Switzerland. Statistics are given on the origin of imports of scientific instruments and apparatus into these countries. Considerable information of a trade and industrial nature is also given.

Association of Chemical Plant Equipment Manufacturers

At a meeting of representatives of manufacturers of chemical plant equipment at the Chemists' Club, New York, on Saturday, Sept. 17, it was decided to form an Association of Chemical Plant Equipment Manufacturers. The object of this association is to further various interests of these manufacturers, which, it is believed, can be promoted more satisfactorily by action as a group rather than as individuals.

The organization committee consists of J. George Lehman, chairman, Bethlehem Foundry & Machine Co.; Paul O. Abbé, Paul O. Abbé, Inc.; A. A. Holmes, E. B. Badger & Sons; Dr. C. H. Kimberly, Schutte & Koerting Co.; P. C. Kingsbury, General Ceramics Co.

Civil Service Examination

The United States Civil Service Commission announces an open competitive examination for associate metallurgist (qualified in foundry practice). Vacancies in the Bureau of Standards, Washington, D. C., at $2,000 to $3,000 a year, and in positions requiring similar qualifications, at these or higher or lower salaries, will be filled from this examination. Applicants should apply on Form 2118 before Oct. 11.

Book Reviews

A DICTIONARY OF APPLIED CHEMISTRY. By *Sir Edward Thorpe*, assisted by eminent contributors. Revised and Enlarged Edition. Vol. I, A-Calcium. 752 pp., illustrated. New York and London: Longmans, Green & Co. Price, $20.

For over thirty years Thorpe's Dictionary has enjoyed the reputation of being the single standard reference book of chemical industry in all English-speaking countries. No other work has ever approached it for thorough, accurate and comprehensive information on industrial chemistry. Several times since the dictionary was first issued the editor and publisher have recognized the necessity for revising the work in order to keep pace with the growth and progressive advance of the science. Each new edition has improved and materially expanded its predecessor and has recorded the

increasing number of developments in the application of chemistry to industry.

During the nine years which have elapsed since the publication of the first volume of the previous edition, tremendous and unprecedented expansion has occurred in the chemical industry of all countries, and there is an evident need for a careful survey and critical summary of this progress. The late war stimulated the application of pure science. Many new products have been developed and many old products have been made by new or improved processes. It is too soon to judge of the permanency of some of these changes perhaps, but it is obvious that many of them represent real and substantial progress. In glancing over the present volume, in a cursory way, to be sure, it is interesting to note the number of these developments which have been recognized and accredited by the authors.

One of the first of the major subjects is the article on Acetic Acid, a section of which has rightfully been devoted to a discussion of the synthesis from acetylene. No mention is made, however, of the commercial developments such as those found in Canada, France and Switzerland. In what appears to be a rather inadequate treatment of Acetone, it is surprising to note that the more modern methods of preparation have not been recognized. The fermentation process and the production from acetylene, both processes which were used on a large scale during the war, are not discussed. Under the subject of Alcohol there is reference to the synthesis from acetylene in Germany and also to the preparation from wood by the Classen process which has been tried out in the United States. However, the development in Great Britain of a process of preparing alcohol from ethylene is apparently passed over without mention. An important contribution to the new edition is the article on Aldehyde. Here we find our references to the synthesis of acetic acid and acetone which we have previously looked for under the names of the respective products. This leads us to point out an objection, or rather an apparently inherent fault of the Dictionary or in fact to any other work of similar arrangement. A simple alphabetical presentation of the subject matter, without abundant (and bothersome) cross-references, often makes it extremely difficult to find the information one desires. A comprehensive index would certainly be a worth-while improvement to the new edition.

There has been notable revision and expansion in the reviews covering Alizarin Dyes and Ammonia. The new anæsthetics developed by the war are recorded. The section dealing with Analysis has been revised and slightly enlarged, and this brings to the reviewer's mind the question of whether such an extended treatise (104 pp.) is not out of place in a dictionary on applied chemistry. It would appear to the reviewer that this space could be better used in emphasizing chemical engineering applications and equipment, a subject in which is treated far too inadequately in most text books. A new article on Organic Arsenicals is a worthy addition to the volume. It is also to be noted that Azo Dyes have been given a somewhat extended treatment to very good advantage.

The reviewer was rather surprised to find that seven pages had been devoted to Bone Oil and the theoretical discussion of its constitution. Cutting the article on Brewing to half the size of the former contribution will probably be somewhat disappointing to the many American readers who have been conducting home experiments in this ancient art. Butyl Alcohol, however, has come to occupy a position of considerable industrial importance and there is no mention of its preparation by the fermentation process or its important application as a solvent.

With this final comment on the contents of the book, the reviewer is tempted to risk, as his opinion, one general fault of the work, past and present editions included. There is an evident failure to recognize American practice in chemical engineering. The emphasis is placed first on the British and then on the Continental methods, while there is seldom a reference to the processes used in the United States. It is natural, of course, that the English work should deal with England, but we believe that many American readers will join us in our rather selfish desire to find an occasional reference to our own way of doing things.

However, it is not our intention to be fault-finding and we have previously referred to the work as "the greatest contribution in English to the literature of applied chemistry." The remaining volumes will be awaited with interest, and it is hoped that they too will record the same improvement that has characterized the first volume of this splendid work.

S. D. KIRKPATRICK.

Personal

Dr. E. M. A. CHANDLER has resigned his position with the Dicks-David Dye Co., Chicago Heights, Ill., to take employment with the Industrial Chemical Laboratory Co., at Hammond, Ind., manufacturer of dye intermediates.

Dr. V. H. GOTTSCHALK, formerly director of research for the American Cotton Oil Co., has accepted a position in the metallurgical engineering department of the Western Electric Co., Chicago, Ill.

WILLIAM MYERS has been engaged by the Bureau of Mines as a member of its non-metals investigation staff. He will be stationed in Washington.

TUDOR S. RODGERS has resigned from the Tecopa Consolidated Mining Co., Inyo County, California, where he was chief chemist and assistant mill superintendent, and is now engaged in the practice of law, with offices in Salt Lake City, Utah.

GEORGE OTIS SMITH, director of the U. S. Geological Survey, will address the annual meeting of the New York State Oil Producers' Association at Olean, N. Y., on Sept. 31. His subject will be "The Real Value of Oil." Dr. Smith has accepted an invitation to address the General Staff College of the Army on Oct. 5 on "Strategy of Minerals." Later in the course he will address the class on "Superpower."

L. J. WALDBAUER has resigned his instructorship at the University of Maine to accept a demonstratorship at McGill University, Montreal, Canada.

J. E. WALTERS, F. W. SCHROEDER and FRANK PORTER, chemists who have been on duty at the helium plant at Petrolia, Tex., have been transferred to Washington, where they have been added to the force at the cryogenic laboratory.

W. M. WEIGEL, of the chemical division of the Bureau of Mines, who has been studying deposits of filler materials in the Southwest, will now visit Eastern plants that are utilizing these materials. This work is being done in connection with the general study of filler problems being made by the bureau.

EDWIN D. WINKWORTH has been named executive vice-president for the Solvay Process Co., in full charge of management of the parent concern of all Solvay interests.

Obituary

Captain ANTHONY F. LUCAS, who was responsible for the famous Lucas gusher at Spindle Top, the pioneer of the Gulf Coast oil development, died in Washington on Sept. 2. Captain Lucas was born in Spalatro, Dalmatia, Austria, in 1855, and possessed all the kindliness and sympathy for others characteristic of the Montenegrin race from which he was descended. He did important work on salt, petroleum and sulphur, it being the oil from Spindle Top, used as fuel, which made possible the development of the Frasch system of mining sulphur. His discoveries had an immense bearing on the development of modern technology, the raw mineral products discovered by him being the incentive for a great deal of engineering progress. He avoided publicity and ceremony and was content with doing for the sake of doing. His life work is catalogued in "Pioneering the Gulf Coast," by R. S. McBeth.

Review of the Industrial Chemical Market Since the Beginning of 1921

THE first eight months of the year have been a mighty disappointment to those who were of the opinion that January, 1921, would see the beginning of a marked revival in the general list. Everyone hoped for the best, but in reality looked for the worst and got the fulfillment of his expectations. The year so far has been filled with more business reverses than have ever before been experienced by the chemical industry, and it is only within the past few weeks that the rays of hope have been penetrating through the edges of passing dark clouds.

There has been some improvement in 1921 when conditions are compared with the acute slump in values during 1920. Conditions have improved steadily since the first of the year insomuch as the rate of loss in values has been steadily diminishing. During the period of the war and immediately after the signing of the armistice spot quotations through speculation rose 300 to 500 per cent above the 1913-1914 normal values. At the beginning of the war the entire list was about 75 per cent above the 1914 average. The loss so far this year has been somewhat around 25 per cent of the inflated figure, bringing an average of industrial chemical values today to about 50 per cent above pre-war figures. Although there are quite a few items that are selling at figures which are actually lower than the pre-war price, the majority of chemicals still stand far above 1914 prices.

The Export Situation

The American chemical industry has suffered greatly during the current year, as far as export business is concerned. European rates of exchange have just about driven the American exporter out of the running. South America has welcomed German commercial representatives aided by a very cheap mark, and has returned to its former source of chemical products. Japan until recently has done only a small amount of chemical business. The Germans are attempting to win back this field and have dumped a large amount of products at much lower than American costs. It seems, however, that the Japanese are looking for American chemicals and have materialized this desire by placing numerous large orders in the market during the past few weeks.

The Import Situation

The chemical import business has progressed markedly in the face of the many adverse conditions. Here and there new houses are being organized to handle European imports. The depreciated mark and franc have given the foreign manufacturer an exceptional opportunity to ship goods into this market at prices with which American producers have been absolutely unable to compete. The biggest portion of the chemical business which has passed in the market since the beginning of the year has been in imported goods. American manufacturers have been looking on, awaiting some action from Congress which will give them a chance to do some business again. While the emergency tariff has kept out all synthetic and coal-tar chemicals, other products have been permitted to flood the market and have been the chief cause in bringing prices down. It is, therefore, quite evident that the export and import situations have been steadily depressing the American manufacturer, making it an impossibility to market his products at prices compatible with American costs of production.

The Tariff Question

The apparent recovery of the German chemical export market, as evidenced by the heavy shipments of potash products to this market and the legislative situation in Washington, has held the center of the domestic chemical stage. Between the dye license clause and the Fordney tariff bill, the chemical industry as a whole has had little peace. The chemical market has been split in many ways by the legislative situation. Manufacturers have been strong in their desire for adequate protection in the form of a high tariff, while opposed to this position stand the large consuming industries and the chemical importers. The frequent large shipments of German material at extremely low prices, especially potash salts, prussiates and bromides, combined with heavy imports of French and British soda ash, have been the big feature in the American producers' fight for protection. The consensus among leading manufacturers is that no definite action on these bills will be taken before some time in December. The chemical and dye industries, in the meantime, have been given protection to some degree by an extension of the emergency tariff to Nov. 27.

The Soda Situation

Prices in the soda industry have not been affected so acutely by importations of foreign goods, because of the fact that imports have come from countries whose exchanges are not so depreciated as is that of Germany. Soda ash imports have come in large quantities chiefly from England and to some degree from France. Caustic soda has not gone below $3.80 per 100 lb. in the resale market and imports have not been at all noticeable. The goods that have arrived in this country have been offered below those at which American makers have offered, but imports have been closely held, so that no excess above consumers' requirements have come into the market to force further decline in quotations. The practice of selling the goods before ordering their import has in no doubt saved the alkali industry from any serious injury. Scarcely an item in the heavy chemical list, with the exception of the heavy acids, has failed to feel the effect of the low exchange and low manufacturing costs abroad. Alums, fluorides, ammonium chloride and prussiates have been subject to the same influences and the result has been that producers of these products have been forced to close their plants or greatly reduce their output.

The Potash Industry

The sharp decline in the potash market was due to the Scandinavian countries, which reshipped large quantities of caustic potash that had been sent to them by American producers in 1919 and 1920. This material was shipped to them with the hope that the peace settlement would leave Germany without potash and that as soon as trade was resumed an open market would be found for it in countries which had previously depended principally on Germany as their source of supply. In spite of the fact that France assumed control of the greater portion of Alsatian deposits, German prices began to slump so rapidly that American manufacturers were forced to close their plants and center their hopes in Congress. Holders of American stocks of potash abroad became convinced that their plans had met utter failure and returned large portions of it to the New York market to be sold as quickly as possible. From that time until a few weeks ago prices slumped tremendously until this reshipped caustic had been absorbed. Prices worked themselves down to as low as 4¼c. per lb. During this time crude muriate of potash, which was held at $2.40 per unit during the summer of 1920, was forced down to the present price of 85c. per unit by the production of the Germans and French, who were endeavoring to place themselves on a better financial footing. The strong competition for the American market has put the domestic producers of crude potash salts under as heavy a handicap as the producers of other potash salts. The heavy freight charges from the western producing districts, together with the more expensive methods of obtaining potash from low-grade ores which it has been necessary to employ as compared with the ordinary procedure required by European salt deposits, have placed the crude potash producers in a very unhealthy position. It is highly questionable if the proposed duties will relieve the situation to any material degree. Manufacturers of potash compounds from this crude material have been forced to use imported raw material, and even then have found it impossible to compete with foreign goods. Their condition is considered more serious when it is to be remembered that the proposed duty on their products is equivalent only to the raw material duty urged to protect the crude potash producers.

Potash Production in Alsace

Reports from Strassburg state that the output of the Alsatian potash mines will be doubled in October, according to a Reuter cable from Paris. It is probable that the monthly production of potassium chloride in 1922 will average about 10,000 tons, a large proportion of which will be available for export.

Hydro-Electric Inspection Tour Planned by Engineering Society of Buffalo

The Engineering Society of Buffalo has planned a novel and interesting meeting for Saturday, Oct. 8. On that date the members of the society will meet at noon and travel by automobile to Niagara Falls, Ont., where they will be taken on an inspection tour of the Chippewa-Queenstown hydro-electric development which is now being completed.

This tour will be conducted by the men in charge of the electrical, hydraulic and construction branches of the work. After the tour the party will return to Buffalo for dinner at the University Club, where addresses will be given by the engineers in charge of the development.

The Rochester Engineering Society and the Niagara Peninsula branch of the Engineering Society of Canada have been invited to accompany the Buffalo Society on this trip.

Chemical Companies Organized

During the month of August, a total of thirty-seven new companies in the chemical industries was organized, with authorized capital of $50,000 or greater. The combined authorized capital of the new concerns totaled $15,495,000, representing the largest monthly total for new companies in this line of business since January last, and indicated a striking contrast with the aggregate for the preceding month of July, which stood at $3,265,000. In August, 1920, the indicated capitalization of new chemical companies was $36,715,000. During the first eight months of the present year, January-August, inclusive, chemical organizations with a combined capitalization of $84,385,000 have been formed, as compared with $167,922,000 for the corresponding period of 1920.

Current Market Reports

The Chemical and Allied Industrial Markets

NEW YORK, Sept. 26, 1921.

Business is showing a decided improvement throughout the list as consumers become more confident of present price levels, and while the market is still somewhat irregular, the movement of stocks is rapidly increasing. The demand, while chiefly from domestic consumers, embraces a moderate amount of foreign requirements. South American countries and Mexico are inquiring for miscellaneous chemicals and sales have been noted in various quarters. Soapmakers have been among the largest purchasers, while glass factories, tanneries, paper and textile mills have all shown a marked improvement in covering their chemical necessities. Quite a number of firms report that business so far this month has been better than during the entire month of August, which was considered the best month since the beginning of the depression. There has been a tendency in several instances to increase the size of commitments and more carlot transactions have been noted in the heavy chemicals. The market, in general, is showing considerable resistance around prevailing levels and there were several instances of net advances at the close of the week.

Solid caustic soda was one of the large items which recorded a firmer tone in the final trading. Advancing prices on caustic potash also featured the week's market. This chemical is sharply higher on diminished spot stocks, and while the foreign markets are showing firmness, it is believed that arrivals will bring prices back to slightly lower levels. Ammonium sulphate is higher both at the works and for export. Sodium nitrate is firmer. Bichromate of soda was another chemical that displayed a splendid tone on spot. The recent advance in prussiate of soda has been well maintained.

Importations of German chemicals have freely continued. Large arrivals of potash products are noted from Hamburg. These, however, did not have any marked depressing influence on values, as it is understood that a large portion of this material was sold to arrive. There have not been any recent importations of foreign caustic soda and soda ash. The price of domestic ash seems low enough to satisfy domestic consumers and they are not desirous of meddling with foreign goods at the present time.

Outside developments during the past week have been of a highly favorable character. The steel industry has shown a noteworthy improvement so far this month. Large steel companies have announced the reopening of their plants on full-time operation and have advanced prices, which have helped decidedly in stimulating new business. The textile industry is gradually forging ahead, while the paper mills are steadily recovering from their adverse conditions noted earlier in the year.

CHEMICALS

Spot *caustic potash* was advanced and the market closed in a firm condition with relatively little stock offered. Shipment prices from Germany have been advanced and it is doubtful if better than 5½c. per lb. would be accepted on the 88-92 per cent. Dealers quote the spot market at 5¾c. per lb. Buyers have not been desirous of following the advance, but it looks as though they will soon be reconciled to the higher trading level. Imported *chlorate of potash* is quoted at 7c. per lb. on spot and 6½c. afloat. Shipments were quoted at 5¼@5¾c. per lb., c.i.f. New York. Domestic material continued unchanged at 12c. per lb., f.o.b. works. Spot *bicarbonate of soda* is offered by dealers at $2.40 per 100 lb. packed in barrels and at $2.75 per 100 lb. in kegs. At the works producers quote 2c. per lb. for barrels and 2¼c. for kegs. A fair inquiry has featured the market for this material, but there has been no unusual change in trading. Closing prices for solid *caustic soda* record a net advance for the week. The demand for this chemical is gradually increasing, while supplies of standard brands are relatively light in second hands. Prices have ranged from $3.90 to $4.05 per 100 lb. during the past week and the final quotation for standard goods was 4c. per lb. Sales have included the wants of both foreign and domestic consumers and the movement is considered quite satisfactory by prominent dealers. Market prices on *nitrate of soda* have been a trifle easier, with sellers at 6¾@7c. per lb., depending upon the quantity. The inquiry continues rather light, with competition somewhat keener for the light passing business. Higher prices have been established for *prussite of soda*, ex-store. The demand at intervals was active, and while small lots commanded the most attention, the aggregate business for the week was well up to the standard. Most of the business went through at 12¾@13c. per lb. Spot prices on *soda ash* have continued firm with an advancing tendency. Large dealers quoted the market for single bags at $2.10@$2.15 per 100 lb. and reported sales at these figures depending upon the quantity involved. Several transactions in barrels were reported at $2.45@$2.50 per 100 lb. Sales of *bleaching powder* in large drums are reported at 2¼c. per lb., f.o.b. works. Sales of imported material are noted at 2c. per lb., ex-dock New York, duty paid. Shipments of foreign material are quoted at $1.90 per 100 lb., and this price was named for goods for arrival in about a week. Several carload lots have changed hands during the week and a good inquiry from the consuming trade was reported from leading makers.

Large sellers of *oxalic acid* quote the market firm at 16½c. per lb. Small lots could probably be purchased in some directions a shade under this figure. The call is mostly for small quantities. At the works 16c. per lb. was named. First-hand sales of *phosphate of soda* are reported on the basis of 4¼c. per lb. for the commercial. The same price was named for *bisodium phosphate*. The U.S.P. variety is quoted by producers at 7½c. per lb. *Copperas* manufacturers quote $18 per ton in bags and up to $23 per ton in barrels

f.o.b. works in large lots. Domestic makers of *strontium nitrate* quote 18@20c. per lb., although it is possible to do 12@12½c. through importers.

Coal-Tar Products

A decided improvement in the sales of intermediates has been made during the past week. The general air of uncertainty, caused by the tariff delay, which has hung over the trade for the past few months, is gradually being dispelled and is giving way to a firm conviction that adequate protection will be accorded to the industry. Consumers in many cases are abandoning hand-to-mouth operations and are placing contracts for good quantities. Resale lots of cheap material are cleaned out in most cases except where manufacturers are using resellers to cover their own unloading operations which have had to go on at sacrifices. For the first time in many months optimism is shown in producing quarters and even those formerly pessimistic are stating that the turn has come. Prices all around are holding steady, but some slight reductions in intermediates were made by makers during the week. Moderate selling of *naphthalene flakes* is going on at 6½@6¾c. per lb. for prime quality goods. Supplies are plentiful and competition for business is keen. First hands quote *aniline oil* at 20c. per lb., but actual sales have been made at 18@18½c. Some resale goods are still obtainable at 17½c. The demand shows considerable improvement and sellers generally are steadier in their views. Most *beta naphthol* sales have been put through at 34c. per lb. First hands continue to quote 40c. per lb., but resale lots are obtainable at 32c. Buying has been moderately active. Sales of *ortho-toluidine* were made at 21c. per lb. and some holders ask up to 25c. The demand is fair. Rumors of lower prices are heard on *alpha-naphthalamine* and there is little doubt that firm business in quantity would bring concessions from makers. Second hands quote from 33@35c. per lb.

Waxes

Importers of *African crude beeswax* report a good volume of business at steady prices. For spot material the market held around 15c. per lb., but on futures as low as 13½c. has been named. *Brazilian crude* was more or less nominal at 21c. per lb. and upward, depending upon seller and color. *White refined wax* was quoted at 36@42c. per lb. The situation on *carnauba wax* presented nothing new, prices holding in sympathy with primary markets. The lower grades were in the best demand and prices for the No. 3 chalky closed at 15@15½c. per lb., with the No. 3 North Country held at 25c. per lb. Holders' views on *Japan wax* were firm due to the recent rise in the cost of import, but the advance has checked buying and prices at the close were more or less nominal at 23@25c. per lb., depending upon the seller and quantity. A moderate improvement was reported in the export demand for *paraffine wax*, but with offerings liberal, prices failed to move upward. Scale wax closed nominally at 1½@2c. per lb., carload basis, f.o.b. works. Export of both crude and refined paraffine for the month of July amounted to 20,876,244 lb., as against 23,583,766 lb. for July a year ago. Exports for the seven months ended with July amounted to 112,101,773 lb., compared with 236,674,790 lb. for the same period a year ago and 128,051,891 lb. in 1919.

The Chicago Market

CHICAGO, Sept. 23, 1921.

All quarters report an increase in business on the general list of industrial chemicals during the past two weeks. Dealers are quite optimistic over the outlook and report conditions as very satisfactory. Prices are firm and holders show no disposition to shade their regular quotations. Stocks are getting low in some quarters, which is a factor to be considered in the firmness of the local market.

Industrial Chemicals

There is a good demand for *caustic soda* in both the ground and solid forms and prices are very firm. The ground 76 per cent is bringing $4.65@$4.80 per 100 lb., according to quantity and holder, and the solid 76 per cent $4.25@$4.37½. *Soda ash* is moving in a very fair way and the price is firm and unchanged at $2.60 per 100 lb. for material in cooperage. *Ammonium chloride* is rather quiet with ample supplies of the white granular available at 7¾c. per lb. *Sulphate of ammonia* has shown a decided firmer tendency during the last few days and it is doubtful if supplies could be had at less than 3¼c. per lb. *Potash alum* is reported to be moving in a fair way at 6c. per lb. for the granulated in barrels. *Aluminum sulphate* is rather scarce and small lots were bringing 2½c. per lb. for the ground iron-free. There is a good demand for *carbon bisulphide* at 7c. and *carbon tetrachloride* at 11c. per lb. Business in *formaldehyde* is rather dull, with dealers quoting 12@12½c. per lb. for single barrels. *Glycerine* is still quiet, with ample supplies of the c.p. material offered at 14c. per lb. Several small sales of *iron sulphate* were noted at 1¾c. per lb.

There is a very good demand for *litharge*, which is quoted by producers at 7½c. per lb. in kegs. *Lead acetate* is said to be selling at a rather brisk rate at 13@13½c. per lb. *Caustic potash* is showing a firmer tendency, with stocks diminishing, and 6½c. per lb. for the 88-92 per cent material was the best offer noted. *Bichromates* are firm as to price and are moving well. *Potash bichromate* is available at 13@13½c. per lb. *Sodium bichromate* on spot is difficult to locate and material to arrive is quoted at 9½c. per lb. There is a fair request for *bicarbonate of soda*, which is firm and unchanged at $2.60 per 100 lb. *Sodium acetate* is moving in a fair way at 5½@6c. per lb. *Hyposulphite of soda* is in good demand and manufacturers are maintaining the price at $4.05 per 100 lb. for the pea crystals in barrels. Several large sales were reported on *sodium fluoride* at 11c. per lb., smaller quantities bringing 12c. *Glauber salts* were available at $1.90 per 100 lb., with a fair movement noted. *Zinc chloride* is in good demand, with prices ranging from 11½c. for the domestic to 9½c. per lb. for the imported.

The list of acids, generally speaking, was maintained as to price. Business in *acetic acid* has shown a decided improvement and prices are firm. The 28 per cent in barrels is quoted at $2.65@$2.75 per 100 lb., according to quantity, and the glacial at $10.25@$10.75 per 100 lb. *Citric acid* is rather slow, with manufacturers quoting 47½c. per lb. for barrels. It is possible to shade this price a few cents in second hands. *Tartaric acid* is in a similar position, first hands asking 35½c. per lb. for barrels. There is a better movement of *sulphuric acid* and the price is maintained at $19@$20 per ton for tank cars, f.o.b. works.

Vegetable Oils

A very good movement of *linseed oil* is reported by dealers. The raw oil is quoted at 76c. per gal. and the boiled at 78c.

Naval Stores

This branch of the trade has nothing to complain of and business is reported as very good. *Turpentine*, as with other paint materials, is moving very well. Today's quotation is 76c. per gal. for drums. There is also a fair demand for *rosins* with carlots of the WW grade quoted at $7.50 per 280 lb. and corresponding prices for the other grades.

The Iron and Steel Market

PITTSBURGH, Sept. 23, 1921.

Last week's advance in prices of wire products, $2 to $3 a ton, has been followed by an advance of $5 a ton in sheets. There are cross-currents, as pipe-mill products, including standard steel pipe, line pipe, oil country goods and boiler tubes, have been formally reduced $8 to $10 a ton, while to complete the divergence, bars, shapes and plates have been practically unchanged in price for a fortnight.

The steadiness in prices of bars, shapes and plates is a plain fact. These commodities are commonly called the "heavy rolled products" and easily comprise the most important part of the finished-steel market in general. The advances and declines referred to above are facts, but they are not so plain. The sheet and wire advances were preceded by heavy bookings at the old prices. It is no secret that the producers took pains to inform buyers that prices were going to be advanced. On the other hand, the formal reduction in pipe-mill products is not as great as appears by the changes from the published lists of July 7 to those of Sept. 16, for the reason that there had been some shading almost from the time the old lists had been put out.

In standard steel pipe the shading averaged about one-half of the formal reduction now made, while in oil country goods the shading was approximately equal to the formal reduction.

Continuous Decline in Steel Prices Ended

Declines in steel prices may not be wholly ended, but the continuous decline is over. For the future we shall have slight ups and downs, for while the general decline is over there is no plain indication that a general and continuous advance has succeeded it. One does not know that the advanced prices for sheets, for instance, will be maintained indefinitely, or be followed by other advances. This may or may not be the case.

Steel prices had declined far enough to represent a very decided liquidation. Taking wire and sheets at their former prices, since buyers are covered at those prices, finished steel products by a weighted average are at 33 per cent above their 1913 average, so frequently taken as a basis of comparison. Thus they would stand at 133 according to the system used by the Bureau of Labor, which reports for August 152 as the index number of wholesale commodity prices in general, made up of individual items ranging from farm products at 118 to house-furnishing goods at 230.

Bars, shapes and plates are generally quotable at 1.65c. In some cases mills may obtain a little more, for small or undesirable orders, while particularly desirable orders may go at slight concessions. There is no hint that as low as 1.50c. has been done in a solitary instance in the past fortnight. Weeks ago some buyers set 1.50c. as the price to which bars, shapes and plates should decline in order to be on a stable basis, but at this date, with wire products and sheets having already reacted upward, it seems safe to conclude that if bars, shapes and plates were going to go to 1.50c. they would already have done so. At some time, doubtless, they will sell below 1.50c., but probably not until fundamental items of cost have experienced reductions that are not in immediate prospect.

Mill Operations

The American Sheet & Tin Plate Co. operated its sheet mills at about 54 per cent last week and scheduled a 70 per cent operation for this week, but the average is likely to be higher. Independent sheet mills recently were operating at about 40 per cent, but are likely to go to an average of 75 per cent or better, disregarding a few plants that are entirely idle. Wire mills are doing better than 50 per cent and pipe mills nearly as well. Bar, shape and plate production is very light and rail production is almost nil, in percentage of actual capacity.

The rate of steel ingot production may be estimated at about 33 per cent, this comparing with an average of 30 per cent in August and a rate just under 20 per cent at the low point, about the middle of July. While demand for wire products, sheets and tubular goods has been improving decidedly, bars, shapes, plates and rails, being heavy products, prevent the production of ingots from showing any great response. The rate of steel production may reach 40 per cent within a short time, but it seems improbable that it will attain 50 per cent at any time this year. Rather strong hopes are entertained for early spring, these hopes being based on a resumption of railroad buying on a fair scale and a decided increase in general construction work.

Pig Iron

Pig iron prices have been well maintained in all districts in the past week and it looks as though prices would tend to advance rather than decline, not on the ground of there being heavy demand, but rather because prices are in most cases below cost of production and the cost of production is not going to experience a decline, by reductions in freight rates, as soon as was expected. The valley market remains quotable at $20 for bessemer, $19 to $20 for basic and $21 for foundry. Inquiry has been very light, since the recent little spurt in activity, but another movement is expected shortly. The Standard Sanitary Manufacturing Co. has just inquired for 4,000 to 5,000 tons of Northern and Southern iron for fourth quarter delivery to its plant in Pittsburgh, New Brighton and Louisville.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	..... -	$0.40 - $0.45
Acetone	lb.	$0.12½ - $0.12½	.13 - .13½
Acid, acetic, 28 per cent	100 lbs.	2.75 - 3.00	3.25 - 3.50
Acetic, 56 per cent	100 lbs.	5.50 - 5.75	6.00 - 6.50
Acetic, glacial, 99½ per cent, carboys,	100 lbs.	10.50 - 11.00	11.25 - 11.50
Boric, crystals	lb.	.12½ - .13	.13½ - .14
Boric, powder	lb.	.13 - .13½	.14 - .14½
Citric	lb.	..... -	.45 - .47
Hydrochloric	100 lb.	1.25 - 1.50	1.60 - 1.75
Hydrofluoric, 52 per cent	lb.	.11½ - .11½	.12 - .12½
Lactic, 44 per cent tech	lb.	.10 - .11	.11½ - .12
Lactic, 22 per cent tech	lb.	.04½ - .05½	.06 - .07
Molybdic, C. P	lb.	4.00 - 4.50	4.50 - 5.00
Muriatic, 20 deg. (see hydrochloric)		..... -	..... - .....
Nitric, 40 deg	lb.	.06½ - .06½	.07 - .07½
Nitric, 42 deg	lb.	.07 - .07½	.07½ - .07½
Oxalic, crystals	lb.	.16½ - .16½	.17 - .18
Phosphoric, 50 per cent solution	lb.	.13 - .13½	.14 - .18
Picric	lb.	.20 - .25	.27 - .35
Pyrogallic, resublimed	lb.	..... -	1.75 - 1.90
Sulphuric, 60 deg., tank cars	ton	..... -	11.75 - 13.00
Sulphuric, 60 deg., drums	ton	..... -	13.00 - 15.00
Sulphuric, 66 deg., tank cars	ton	18.00 - 20.00	..... - .....
Sulphuric, 66 deg., drums	ton	21.00 - 22.00	22.50 - 23.00
Sulphuric, 66 deg., carboys	ton	..... -	..... - .....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	21.00 - 22.00	..... - .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	23.00 - 23.50	24.00 - 24.50
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	31.00 - 32.00	33.00 - 34.00
Tannic, U. S. P	lb.	..... -	.75 - .85
Tannic (tech.)	lb.	.45 - .48	.50 - .55
Tartaric, imported crystals	lb.	..... -	.25 - .26
Tartaric acid, imported, powdered	lb.	..... -	.27 - .28
Tartaric acid, domestic	lb.	..... -	..... - .35
Tungstic, per lb. of WO	lb.	..... -	1.30 - 1.40
Alcohol, Ethyl	gal.	....	4.65 - 4.90
Alcohol, Methyl (see methanol)		..... -	..... - .....
Alcohol, denatured, 188 proof	gal.	..... -	.35 - .36
Alcohol, denatured, 190 proof	gal.	..... -	.37 - .38
Alum, ammonia lump	lb.	.03½ - .03½	.04 - .04½
Alum, potash lump	lb.	.03½ - .04	.04½ - .04½
Alum, chrome lump	lb.	.10 - .11	.11½ - .12½
Aluminum sulphate, commercial	lb.	.02 - .02½	.02½ - .02½
Aluminum sulphate, iron free	lb.	.03 - .03½	.03½ - .04
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ - .07½	.08 - .08½
Ammonia, anhydrous, cyl. (100-150 lb.)	lb.	.30 - .32	.33 - .35
Ammonium carbonate, powder	lb.	.07 - .07½	.08 - .09
Ammonium chloride, granular (white salammoniac)	lb.	.06 - .06½	.06½ - .07
Ammonium chloride, granular (gray salammoniac)	lb.	.06½ - .07	.07½ - .08
Ammonium nitrate	lb.	.07 - .07½	.07½ - .08½
Ammonium sulphate	100 lb.	2.20 - 2.25	2.30 - 2.40
Amylacetate	gal.	..... -	3.25 - 3.50
Amylacetate tech	gal.	..... -	2.50 - 3.00
Arsenic oxide, (white arsenic) powdered	lb.	.05½ - .06	.06½ - .06½
Arsenic, sulphide, powdered (red arsenic)	lb.	.11 - .11½	.12 - .13
Barium chloride	ton	43.00 - 45.00	46.00 - 49.00
Barium dioxide (peroxide)	lb.	.20 - .21	.22 - .23
Barium nitrate	lb.	.07½ - .08	.08½ - .09
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ - .04½	.04½ - .05½
Bleaching powder (see calc. hypochlorite)		..... -	..... - .....
Blue vitriol (see copper sulphate)		..... -	..... - .....
Borax (see sodium borate)		..... -	..... - .....
Brimstone (see sulphur, roll)		..... -	..... - .....
Bromine	lb.	.27 - .28	.28½ - .30
Calcium acetate	100 lbs.	2.00 - 2.05	..... - .....
Calcium carbide	lb.	.04½ - .04½	.05 - .05½
Calcium chloride, fused, lump	ton	23.50 - 24.00	24.50 - 25.50
Calcium chloride, granulated	lb.	.01½ - .02	.02½ - .02½
Calcium hypochlorite (bleach'g powder)	100 lb.	2.75 - 2.80	2.90 - 3.50
Calcium peroxide	lb.	..... -	1.40 - 1.50
Calcium phosphate, tribasic	lb.	..... -	.15 - .16
Camphor	lb.	..... -	.68 - .70
Carbon bisulphide	lb.	.06 - .06½	.06½ - .07½
Carbon tetrachloride, drums	lb.	.10½ - .10½	.11 - .12
Carbonyl chloride (phosgene)	lb.	..... -	.60 - .75
Caustic potash (see potassium hydroxide)		..... -	..... - .....
Caustic soda (see sodium hydroxide)		..... -	..... - .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.08 - .09	.09½ - .10
Chloroform	lb.	..... -	.38 - .43
Cobalt oxide	lb.	..... -	2.00 - 2.10
Copperas (see iron sulphate)		..... -	..... - .....
Copper carbonate, green precipitate	lb.	.19 - .19½	.20 - .21
Copper cyanide	lb.	..... -	.50 - .62
Copper sulphate, crystals	lb.	.05½ - .05½	.05½ - .06
Cream of tartar (see potassium bitartrate)		..... -	..... - .....
Epsom salt (see magnesium sulphate)		..... -	..... - .....
Ethyl Acetate Com. 85%	gal.	..... -	1.00 - 1.10
Ethyl Acetate pure (acetic ether 98% to 100%)	lb.	..... -	.40 - .42
Formaldehyde, 40 per cent	lb.	.12 - .12½	.12½ - .13½
Fusel oil, ref	gal.	..... -	3.25 - 3.75
Fusel oil, crude	gal.	..... -	1.50 - 1.75
Glauber's salt (see sodium sulphate)		..... -	..... - .....
Glycerine, C. P. drums extra	lb.	..... -	.14½ - .15
Iodine, resublimed	lb.	..... -	3.50 - 3.60
Iron oxide, red	lb.	..... -	.10 - .20
Iron sulphate (copperas)	ton	18.00 - 19.00	20.00 - 23.00
Lead acetate	lb.	..... -	.10½ - .12½
Lead arsenate, paste	lb.	.09 - .09½	.10 - .11
Lead nitrate	lb.	..... -	.15 - .20
Litharge	lb.	.07½ - .08	.08½ - .09
Lithium carbonate	lb.	..... -	1.30 - 1.40
Magnesium carbonate, technical	lb.	.08 - .08½	.09 - .10
Magnesium sulphate, U. S. P	100 lb.	2.50 - 2.75	..... - .....
Magnesium sulphate, technical	100 lb.	..... -	1.10 - 1.75
Methanol, 95%	gal.	..... -	.66 - .68
Methanol, 97%	gal.	..... -	.70 - .72
Nickel salt, double	lb.	..... -	.12 - .12½
Nickel salt, single	lb.	..... -	.14 - .14½
Phosgene (see carbonyl chloride)		..... -	..... - .....
Phosphorus, red	lb.	.40 - .41	.42 - .45
Phosphorus, yellow	lb.	..... -	.30 - .35
Potassium bichromate	lb.	.11½ - .11½	.12 - .12½

		Carlots	Less Carlots
Potassium bitartrate (cream of tartar)	lb.	$ .. – $....	$0.26 – $0.28
Potassium bromide, granular	lb.	..... –	.15 – .23
Potassium carbonate, U. S. P.	lb.	.35 – .40	.45 – .50
Potassium carbonate, 80–85%	lb.	.05 – .05½	.06 – .06½
Potassium chlorate, crystals	lb.	.07 – .07½	.07½ – .10
Potassium cyanide	lb	..... –	.26 – .28
Potassium hydroxide (caustic potash)	lb.	.05½ – .05¾	.06 – .08
Potassium muriate, 80% K.C.L.	ton	40.00 – 42.50	..... – .....
Potassium iodide	lb.	..... –	2.75 – 3.00
Potassium nitrate	lb.	.09½ – .09½	.10 – .12½
Potassium permanganate	lb.	.20 – .21	.22 – .23
Potassium prussiate, red	lb.	.28 – .29	.29½ – .30
Potassium prussiate, yellow	lb.	.20 – .20½	.21 – .22
Potassium sulphate (powdered)	per unit	..... –	1.20 – 1.25
Rochelle salts (see sodium potas tartrate)		....	..... – .....
Salammoniac (see ammonium chloride)		....	..... – .....
Sal soda (see sodium carbonate)		..... –	..... – .....
Salt cake (bulk)	ton	..... –	20.00 – 25.00
Silver cyanide	oz.	..... –	1.35 – 1.38
Silver nitrate	oz.	..... –	.41½ – .42
Soda ash, light	100 lb.	2.10 – 2.15	2.20 – 2.50
Soda ash, dense	100 lb.	2.35 – 2.40	2.45 – 2.70
Sodium acetate	lb.	.04 – .04¼	.04½ – .05
Sodium bicarbonate	100 lb.	2.00 – 2.25	2.50 – 2.75
Sodium bichromate	lb.	.07½ – .08	.08½ – .08¾
Sodium bisulphate (nitre cake)	ton	5.00 – 5.25	5.50 – 6.50
Sodium bisulphite powdered, U.S.P.	lb.	.04½ – .05	.05½ – .06
Sodium borate (borax)	lb.	.05½ – .06	.06½ – .07
Sodium carbonate (sal soda)	100 lb.	1.90 – 2.00	2.10 – 2.40
Sodium chlorate	lb.	.07½ – .07¾	.08 – .08½
Sodium cyanide	lb.	.20 – .21	.22 – .30
Sodium fluoride	lb.	.10½ – .11	.11½ – .12
Sodium hydroxide (caustic soda)	100 lb.	4.00 – 4.10	4.15 – 4.75
Sodium hyposulphite	lb	..... –	.03½ – .03¾
Sodium nitrate	100 lb.	2.20 –	2.35 – .....
Sodium nitrite	lb.	.06½ – .07	.07½ – .07¾
Sodium peroxide, powdered	lb.	.25 – .26	.27 – .30
Sodium phosphate, dibasic	lb.	.04½ – .04¾	.04¾ – .05½
Sodium potassium tartrate (Rochelle salts)	lb.	..... –	.21 – .24
Sodium prussiate, yellow	lb.	.12½ – .13	.13½ – .14
Sodium silicate, solution (40 deg.)	100 lb.	1.00 – 1.15	1.25 – 1.40
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.03½ – .03¾
Sodium sulphate, crystals (Glauber's salt)	100 lbs.	1.50 – 1.75	2.00 – 2.25
Sodium sulphide, fused, 60–62 per cent (conc.)	lb.	.04½ – .04¾	.05 – .06
Sodium sulphite, crystals	lb.	.03½ – .04	.04½ – .04¾
Strontium nitrate, powdered	lb.	.12 – .13	.13½ – .20
Sulphur chloride, red	lb.	.05 – .05½	.05½ – .06½
Sulphur, crude	ton	18.00 – 20.00	..... – .....
Sulphur dioxide, liquid, cylinders extra	lb.	.08 – .08½	.09 – .10
Sulphur (sublimed), flour	100 lb.	..... –	2.25 – 3.10
Sulphur, roll (brimstone)	100 lb.	..... –	2.00 – 2.75
Tin bichloride, 50 per cent	lb	.18 – .19	..... – .....
Tin oxide	lb.	..... –	.38 – .40
Zinc carbonate, precipitate	lb.	.16 – .16½	.17 – .17½
Zinc chloride, gran	lb.	.09½ – .09½	.10 – .11
Zinc cyanide	lb.	.42 – .44	.45 – .47
Zinc dust	lb.	.11½ – .11½	.11½ – .12½
Zinc oxide, XX	lb.	.07½ – .07¾	.08 – .09
Zinc sulphate	100 lb.	3.00 – 3.25	3.30 – 3.50

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	$1.15 — $1.20
Alpha-naphthol, refined	lb.	1.35 — 1.40
Alpha-naphthylamine	lb.	.35 — .40
Aniline oil, drums extra	lb.	.17½ — .20
Aniline salts	lb.	.24 — .26
Anthracene, 80% in drums (100 lb.)	lb.	.75 — 1.00
Benzaldehyde U.S.P.	lb.	1.00 — 1.25
Benzidine, base	lb.	1.00 — 1.10
Benzidine sulphate	lb	.75 — .85
Benzoic acid, U.S.P.	lb.	.70 — .72
Benzoate of soda, U.S.P.	lb.	.55 — .60
Benzene, pure, water-white, in drums (100 gal.)	gal.	.27 — .32
Benzene, 90%, in drums (100 gal.)	gal.	.25 — .28
Benzyl chloride, 95-97%, refined	lb.	.25 — .27
Benzyl chloride, tech	lb.	.20 — .23
Beta-naphthol benzoate	lb.	3.50 — 4.00
Beta-naphthol, sublimed	lb.	.70 — .75
Beta-naphthol, tech	lb.	.32 — .35
Beta-naphthyla mine, sublimed	lb.	1.90 — 2.00
Cresol, U. S. P., in drums (100 lb.)	lb.	.17 — .19
Ortho-cresol, in drums (100 lb.)	lb.	.25 — .27
Cresylic acid, 97–99%, straw color, in drums	gal.	.70 — .75
Cresylic acid, 95-97%, dark, in drums	gal.	.60 — .65
Cresylic acid, 50%, first quality, drums	gal	.45 — .50
Dichlorbenzene	lb.	.06 — .09
Diethylaniline	lb.	1.20 — 1.25
Dimethylaniline	lb.	.42 — .50
Dinitrobenzene	lb.	.25 — .28
Dinitroclorbenzene	lb.	.25 — .30
Dinitronaphthalene	lb.	.32 — .40
Dinitrophenol	lb.	.37 — .40
Dinitrotoluene	lb.	.25 — .30
Dip oil, 25%, car lots, in drums	gal.	.35 — .40
Diphenylamine	lb.	.60 — .70
H-acid	lb.	1.10 — 1.20
Meta-phenylenediamine	lb.	1.15 — 1.20
Monochlorbenzene	lb.	.12 — .14
Monoethylaniline	lb.	1.50 — 1.60
Naphthalene crushed, in bbls.	lb.	.06½ — .07¼
Naphthalene, flake	lb.	.06½ — .08
Naphthalene, balls	lb.	.08 — .09½
Naphthionic acid, crude	lb.	.70 — .75
Nitrobenzene	lb.	.12 — .15
Nitro-naphthalene	lb.	.30 — .35
Nitro-toluene	lb.	.15 — .17
Ortho-amidophenol	lb.	3.00 — 3.10
Ortho-dichlor-benzene	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.75 — .80
Ortho-nitro-toluene	lb.	.15 — .20
Ortho-toluidine	lb.	.21 — .25
Para-amidophenol, base	lb.	1.40 — 1.45
Para-amidophenol, HCl	lb.	1.70 — 1.80
Para-dichlorbenzene	lb.	.15 — .20
Paranitroaniline	lb.	.79 — .82
Para-nitrotoluene	lb.	.80 — .85
Para-phenylenediamine	lb.	1.70 — 1.75
Para-toluidine	lb.	1.25 — 1.40
Phthalic anhydride	lb.	.40 — .50
Phenol, U. S. P., drums	lb.	.08½ — .10
Pyridine	gal.	2.00 — 3.50
Resorcinol, technical	lb.	1.50 — 1.60
Resorcinol, pure	lb.	2.25 — 2.30
Salicylic acid, tech., in bbls.	lb.	.18 — .20
Salicylic acid, U. S. P.	lb.	.19 — .22
Salol	lb.	.60 — .70
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25 — .28
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.14 — .16
Sulphanilic acid, crude	lb.	.27 — .30
Toluidine	lb.	1.30 — 1.35
Toluidine, mixed	lb.	.43 — .45
Toluene, in tank cars	gal.	.25 — .28
Toluene, in drums	gal.	.28 — .31
Xylidines, drums, 100 gal.	lb.	.40 — .45
Xylene, pure, in drums	gal.	.40 — .45
Xylene, pure, in tank cars	gal.	.45 — ....
Xylene, commercial, in drums, 100 gal.	gal.	.33 — .35
Xylene, commercial, in tank cars	gal.	.30 — ....

Waxes

Prices based on original packages in large quantities.

Bayberry Wax	lb.	$0.20 —	$0.21
Beeswax, refined, dark	lb.	.24 —	.25
Beeswax, refined, light	lb.	.28 —	.30
Beeswax, white pure	lb.	.36 —	.42
Candelilla wax	lb.	.25 —	.26
Carnauba, Flora	lb.	.48 —	.50
Carnauba, No. 2, North Country	lb.	.25 —	.26
Carnauba, No. 3, North Country	lb.	.15 —	.15½
Japan	lb.	.23 —	.24
Montan, crude	lb.	.05½ —	.06
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.03½ —	.03¾
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.02 —	....
Paraffine waxes, refined, 118-120 m.p.	lb.	.03 —	.03¾
Paraffine waxes, refined, 125 m.p.	lb.	.03½ —	.03¾
Paraffine waxes, refined, 128-130 m.p.	lb.	.03½ —	.04¼
Paraffine waxes, refined, 133-135 m.p.	lb.	.04½ —	.05
Paraffine waxes, refined, 135-137 m.p.	lb.	.05½ —	.06
Stearic acid, single pressed	lb.	.09½ —	....
Stearic acid, double pressed	lb.	.10½ —	....
Stearic acid, triple pressed	lb.	.11 —	.11½

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbl. gross weight, 500 lb.

Rosin B-D, bbl.	280 lb.	$5.80 —	5.90
Rosin E-I	280 lb.	6.00 —	6.50
Rosin K-N	280 lb.	6.60 —	7.00
Rosin W. G.-W. W.	280 lb.	7.15 —	7.65
Wood rosin, bbl.	280 lb.	6.25 —	.....
Spirits of turpentine	gal.	.79½ —	.....
Wood turpentine, steam dist.	gal.	.77 —	.....
Wood turpentine, dest. dist.	gal.	.76 —	.....
Pine tar pitch, bbl.	200 lb.	..... —	6.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	..... —	11.00
Retort tar, bbl.	500 lb.	..... —	11.00
Rosin oil, first run	gal.	.35 —	.....
Rosin oil, second run	gal.	.37 —	.....
Rosin oil, third run	gal.	.44 —	.....
Pine oil, steam dist., sp.gr., 0.930-0.940	gal.		$1.90
Pine oil, pure, dest. dist.	gal.		1.50
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.		.46
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.		.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.		.75
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.		.35
Turpentine, crude, sp. gr., 0.900-0.970	gal.		1.25
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.		.35
Pinewood creosote, ref.	gal.		.52

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.37
70-72 deg., steel bbls. (85 lb.)	gal.	.35
68-70 deg., steel bbls. (85 lb.)	gal.	.34
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23

Crude Rubber

Para—Upriver fine	lb.	$0.16 —	.17
Upriver coarse	lb.	.09 —	.09½
Upriver caucho ball	lb.	.11½ —	.12
Plantation—First latex crepe	lb.	.14 —	.....
Ribbed smoked sheets	lb.	.12 —	.12½
Brown crepe, thin, clean	lb.	.15 —	.....
Amber crepe No. 1	lb.	.17 —	.....

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.09½ —	$0.09¾
Castor oil, AA, in bbls.	lb.	.10¾ —	.11¼
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.11½ —	.12
Cocoanut oil, Ceylon grade, in bbls.	lb.	.10 —	.10¼
Cocoanut oil, Cochin grade, in bbls.	lb.	.10¾ —	.11¼
Corn oil, crude, in bbls.	lb.	.08¾ —	.09
Cottonseed oil, crude (f. o. b. mill)	lb.	.08¼ —	.08½
Cottonseed oil, summer yellow	lb.	.10¼ —	.10¾
Cottonseed oil, winter yellow	lb.	.11 —	.11¼
Linseed oil, raw, car lots (domestic)	gal.	.73 —	.74
Linseed oil, raw, tank cars (domestic)	gal.	.67 —	.68
Linseed oil, in 5-bbl lots (domestic)	gal.	.76 —	.77

Olive oil, Denatured	gal.	$1.10 —	$1.20
Palm, Lagos	lb.	.08 —	.08½
Palm, Niger	lb.	.06½ —	.06½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.08½ —	.08½
Peanut oil, refined, in bbls	lb.	.10½ —	.10½
Rapeseed oil, refined in bbls	gal.	.86 —	.88
Rapeseed oil, blown, in bbls	gal.	.90 —	.92
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.08½ —	....
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.07½ —	....
FISH			
Light pressed menhaden	gal.	$0.40 —	....
Yellow bleached menhaden	gal.	.42 —	....
White bleached menhaden	gal.	.44 —	....
Blown menhaden	gal.	.48 —	....

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$24.00 —	30.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	22.00 —	26.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	10.00 —	12.00
Barytes, floated, f.o.b. St. Louis	net ton	23.00 —	24.00
Barytes, crude, first grade, Missouri	net ton	7.00 —	....
Blanc fixe, dry	lb.	.04 —	.04½
Blanc fixe, pulp	net ton	45.00 —	55.00
Casein	lb.	.06 —	.07
Chalk, Precipitated, domestic, extra light	lb.	.04½ —	.05
Chalk, Precipitated, domestic, light	lb.	.04 —	.04½
Chalk, Precipitated, domestic, heavy	lb.	.03½ —	.04
Chalk, Precipitated, English, extra light	lb.	.04½ —	.05
Chalk, Precipitated, English, light	lb.	.04½ —	.05
Chalk, Precipitated, English, dense	lb.	.04 —	.04½
China clay (kaolin) crude, f.o.b. mines, Georgia	net ton	6.50 —	8.50
China clay (kaolin) washed, f.o.b. Georgia	net ton	9.00 —	10.00
China clay (kaolin) powdered, f.o.b. Georgia	net ton	13.00 —	20.00
China clay (kaolin) crude f.o.b. Virginia points	net ton	8.00 —	12.00
China clay (kaolin) ground, f.o.b. Virginia points	net ton	13.00 —	20.00
China clay (kaolin), imported, lump	net ton	12.00 —	20.00
China clay (kaolin), imported, powdered	net ton	25.00 —	30.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	net ton	5.00 —	7.50
Feldspar, crude, f.o.b. Maine	net ton	7.50 —	10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00 —	23.00
Feldspar, ground, f.o.b. North Carolina	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. Baltimore	net ton	27.00 —	30.00
Fullers earth, f.o.b. Mines	net ton	16.00 —	17.00
Fullers earth, granular, f.o.b. Fla	net ton	15.00 —	18.00
Fullers earth, powdered, f.o.b. Fla	net ton	18.00 —	....
Fullers earth, imported, powdered	net ton	24.00 —	27.00
Graphite, Ceylon lump, first quality	lb.	.06 —	.07
Graphite, Ceylon chip	lb.	.04½ —	.05
Graphite, high grade amorphous crude	lb.	.00½ —	.02½
Kieselguhr, f.o.b. mines, Cal	per ton	40.00 —	....
Kieselguhr, f.o.b. N.Y	per ton	61.00 —	....
Magnesite, calcined	per ton	66.00 —	70.00
Pumice stone, imported, lump	lb.	.03 —	.40
Pumice stone, domestic lump	lb.	.05 —	.05½
Pumice stone, ground	lb.	.06 —	.07
Quartz (acid tower) first to head, f.o.b. Baltimore	net ton	..... —	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	..... —	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	..... —	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00 —	7.50
Shellac, orange fine	lb.	.50 —	.51
Shellac, orange superfine	lb.	.51 —	.52
Shellac, A. C. garnet	lb.	.44 —	.45
Shellac, T. N	lb.	.44 —	.45
Soapstone	ton	12.00 —	15.00
Sodium chloride	long ton	12.50 —	13.00
Talc, paper-making grades, f.o.b. Vermont	ton	11.00 —	18.00
Talc, roofing grades, f.o.b. Vermont	ton	8.50 —	13.00
Talc, rubber grades, f.o.b. Vermont	ton	11.00 —	18.00
Talc, powdered, Southern, f.o.b. cars	ton	7.50 —	11.00
Talc, imported	ton	30.00 —	40.00
Talc, California talcum powder grade	ton	*8.00 —	25.00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh	per ton		$50.00
Carborundum refractory brick, 9-in.	less than carlot	1,000	1250.00
	carload lots	1,000	1100.00
Chrome brick, f.o.b. Eastern shipping points	net ton		52- 55
Chrome cement, 40-45% Cr_2O_3	net ton		30- 32
Chrome cement, 40-45% Cr_2O_3, sacks, in car lots, f.o.b. Eastern shipping points	net ton		33- 35
Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		35- 40
Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		30- 35
Magnesite brick, 9-in. straight	net ton		65- 70
Magnesite brick, 9-in. arches, wedges and keys	net ton		77
Magnesite brick, soaps and splits	net ton		98
Silica brick, 9-in. sizes, f.o.b. Chicago district	1,000		40- 42
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000		42- 45
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa	1,000		35- 38

Ferro-Alloys

All f.o.b. Works

Ferro-titanium, 15-18%, f.o.b. Niagara Falls, N. Y	net ton	$200.00 —	$225.00
Ferrochrome per lb. of Cr. contained, 6-8% carbon, carlots	lb.	.11 —	....
Ferrochrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	.11 —	12
Ferromanganese, 76-80% Mn, domestic	gross ton	60.00 —	63.00
Ferromanganese, 76-80% Mn, English	gross ton	63.00 —	65.00
Spiegeleisen, 18-22% Mn	gross ton	25.00 —	27.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo	lb.	2.25 —	....
Ferrosilicon, 10-15%	gross ton	38.00 —	40.00
Ferrosilicon, 50%	gross ton	60.00 —	65.00
Ferrosilicon, 75%	gross ton	130.00 —	135.00
Ferrotungsten, 70-80%, per lb. of contained W	lb.	.40 —	.45
Ferrouranium, 35-50% of U, per lb. of U content	lb.	6.00 —	....
Ferrovanadium, 30-40% per lb. of contained V	lb.	4.25 —	4.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content	net ton	$8.00 —	$10.00
Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	ton	25.00 —	27.00
Chrome ore, 50% Cr_2O_3, f.o.b. Atlantic seaboard	ton	25.00 —	27.00
Coke, foundry, f.o.b. ovens	net ton	4.25 —	4.50
Coke, furnace, f.o.b. ovens	net ton	3.25 —	3.50
Coke, petroleum, refinery, Atlantic seaboard	net ton	12.00 —	13.00
Fluorspar, lump, f.o.b. mines, New Mexico	net ton	12.50 —	....
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	20.00 —	22.00
Ilmenite, 52% TiO_2, per lb. ore	lb.	.01½ —	.01½
Manganese ore, 50% Mn, c.i.f. Atlantic seaport	unit	.20 —	.21
Manganese ore, chemical (MnO_2)	net ton	50.00 —	55.00
Molybdenite, 85% MoS_2, per lb. of MoS_2, N. Y.	lb.	.55 —	.60
Monazite, per unit of ThO_2, c.i.f., Atlantic seaport	unit	30.00 —	....
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	.12 —	.12
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport	unit	.13 —	.13
Pyrites, domestic, fines, f.o.b. mines, Ga	unit	.11 —	.12
Rutile, 95% TiO_2 per lb. ore	lb.	.15 —	....
Tungsten, scheelite, 60% WO_3 and over, per unit of WO_3 (nominal)	unit	2.75 —	3.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3, N. Y. C	unit	3.00 —	3.25
Uranium ore (carnotite) per lb. of U_3O_8	lb.	1.50 —	2.50
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.25 —	2.50
Vanadium pentoxide, 99%	lb.	12.00 —	14.00
Vanadium ore, per lb. of V_2O_5 contained	lb.	1.00 —	....
Zircon, washed, iron free	lb.	.03 —	....

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	12.125
Aluminum, 98 to 99 per cent	24.5@25
Antimony, wholesale lots, Chinese and Japanese	4.45@4.50
Nickel, ordinary (ingot)	41.00
Nickel, electrolytic	44.00
Monel metal, shot and blocks	35.00
Monel metal ingots	38.00
Monel metal, sheet bars	40.00
Tin, 5-ton lots, Straits	26.625
Lead, New York, spot	4.65
Lead, E. St. Louis, spot	4.45
Zinc, spot, New York	4.50@4.55
Zinc, spot, E. St. Louis	4.17½

OTHER METALS

Silver (commercial)	oz.	$0.68½
Cadmium	lb.	1.00–1.25
Bismuth (500 lb. lots)	lb.	1.50@1.55
Cobalt	lb.	3.00@3.25
Magnesium (f.o.b. Philadelphia)	lb.	1.25
Platinum	oz.	72.00@78.00
Iridium	oz.	160.00@170.00
Palladium	oz.	52.00–55.00
Mercury	75 lb.	39.00–41.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	19.50
Copper bottoms	27.00
Copper rods	18.00@18.75
High brass wire	15.75
High brass rods	13.25
Low brass wire	17.25
Low brass rods	17.25
Brazed brass tubing	25.00
Brazed bronze tubing	29.75
Seamless copper tubing	19.50
Seamless high brass tubing	18.00

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York Current	Cleveland	Chicago
Copper, heavy and crucible	9.50@10.00	9.25	9.50
Copper, heavy and wire	9.00@9.25	8.50	8.50
Copper, light and bottoms	7.50@8.00	7.50	7.25
Lead, heavy	3.25@3.50	3.25	3.25
Lead, tea	2.25@2.35	2.25	2.25
Brass, heavy	4.25@4.50	4.50	5.00
Brass, light	3.25@3.50	3.25	3.50
No. 1 yellow brass turnings	4.00@4.25	4.25	4.50
Zinc	2.00@2.25	2.00	2.25

Structural Material

The following base prices per 100 lb. aref or structural shapes 3 in. by ¼ in. and arger, and plates ¼ in and heavier, from jobbers' warehouses in the cities named:

	New York	Cleveland	Chicago
Structural shapes	$2.88	$2.88	$2.88
Steel bars	2.78	2.78	2.78
Soft steel bar shapes	2.78	2.78	2.78
Soft steel bands	3.42	3.48	3.48
Plates, ¼ to 1 in. thick	2.88	2.80	2.80

*Add 15c per 100 lb. for trucking to Jersey City and 10c for delivery in New York and Brooklyn

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

RICHMOND—The Republic Steel Package Co., 7930 Jones Road, Cleveland, O., has plans nearing completion for the construction of its proposed new plant on property recently acquired at Richmond. A railroad line is being constructed to the site. The initial plant unit will be 1-story, 60 x 300 ft., and will be equipped to give employment to about 100 operatives. S. B. Merry is treasurer.

SAN FRANCISCO—The Western Pipe & Steel Co., 444 Market St., is planning for the early operation of its new works at South San Francisco, comprising the former plant of the Shaw-Batcher Shipbuilding Co. Remodeling work is under way and a number of extensions and improvements will be made, with the installation of equipment for the manufacture of steel pipe, tanks, well casings and kindred products. Employment will be given to about 500 men.

Illinois

HAMILTON — The Champion Coated Paper Co. is completing plans for the construction of a 4-story and basement plant addition on North B St., 35 x 185 ft., estimated to cost about $50,000. Peter S. Thompson is president.

Kentucky

BOWLING GREEN—The Hillman Syndicate is perfecting plans for the erection of a new local oil refinery, estimated to cost in excess of $150,000, including equipment.

BOWLING GREEN—E. J. Riggs and associates are organizing a new company to construct and operate an oil-refining plant on local site. The refinery will have an initial daily capacity of about 300 bbl. and is estimated to cost approximately $125,000.

Maryland

BALTIMORE—The United States Industrial Chemical Co., Fairfield Road, has filed plans for the erection of a 1-story addition to its plant, 42 x 112 ft.

BALTIMORE—The Fleischmann Co., North Ave., will commence operations at once at its new local yeast-manufacturing plant, occupying a large site at Central Ave. and Bank St. The structure with machinery represents an investment of close to $3,000,000, and forms the third plant of the company in this city.

BALTIMORE—The Cooknut Corp., Lexington and Paca Sts., has awarded a contract to the Charles L. Stockhausen Co., Inc., 33 South Gay St., for the erection of its proposed new plant on Canton St. for the manufacture of lard substitutes and kindred products. The works will consist of a main 4-story and basement factory, 88 x 100 ft., with 1-story extension, 50 x 56 ft. A 1-story machine shop 35 x 50 ft., will also be constructed. The buildings will be of reinforced concrete and are estimated to cost close to $125,000. W. R. Spruill is president.

Massachusetts

WALTHAM—The Elastoid Fibre Co. has awarded a contract to the H. P. Cummings Cons. Co., Ware, Mass., for the construction of a new 1-story plant on Lexington St., 70 x 180 ft., to be equipped for the manufacture of fiber products.

Minnesota

PAYNESVILLE—The Farmers Mill Co., J. Z. Jerabek, secretary, has awarded a contract to the T. E. Ibberson Co., Corn Exchange Bldg., Minneapolis, Minn., for the erection of its proposed new flour mill. The structure is estimated to cost in excess of $80,000.

Montana

BUTTE—The Cascade Silver Mines & Mills Co. is planning for the rebuilding of its concentrating plant at Neihart, Mont., recently destroyed by fire. The company will also build a new zinc-smelting plant in the same district.

Nebraska

OMAHA—Fire, Sept. 11, destroyed the plant of the Eckman Chemical Co., 16th St., with loss estimated at about $60,000. The works will be rebuilt.

New Jersey

HOBOKEN—The White Metal Mfg. Co., Grand St. near Eleventh St., has completed plans and will soon call for bids for the erection of its proposed new plant on Grand St. It will comprise a main 6-story building, with 1-story structure adjoining, 58 x 65 ft., and 136 x 136 ft., to be used for general production. Joseph C. Schaeffler, 11 East Fifty-sixth St., New York, is architect.

BAYONNE—The Standard Oil Co., Twenty-second St., has filed plans for extensions in the tankage department at its local oil refinery to cost about $115,000.

NEWARK—The Wallington Leather Co., 46 Kent St., has filed plans for the erection of a new 2-story leather-manufacturing plant, estimated to cost about $22,000.

NEWARK — The Butterworth-Judson Corp., Doremus Ave., manufacturer of chemicals, dyes, etc., is arranging plans for reorganization. It is proposed to form a new company to take over the property and assets of the present corporation, and continue plant operations. The new organization will issue bonds for $2,600,000, for general financing, operations, extensions, etc.

FLORENCE—The Florence Pipe Foundry is considering the erection of a new 1-story foundry for the manufacture of iron and steel castings. It will be about 40 x 100 ft. C. L. Reeves is superintendent.

MILFORD—The Warren Mfg. Co., manufacturer of paper, has placed all units of its local plant in operation, including three paper-manufacturing machines and subsidiary equipment. Tentative plans are under way for enlargements at the local mill, due to the permanent closing of the company's plant at Riegelsville, Pa. Equipment now at the latter plant will be removed to Milford, as well as certain machinery to the branch mills at Hughesville and Warren Glen.

New York

ENDICOTT—Walter D. Johnson, operating a local leather-manufacturing plant, has had plans prepared for the erection of a 2-story addition, 40 x 100 ft. Construction will be commenced at an early date.

BROOKLYN—Fire recently destroyed a portion of the plant of the Manhattan Shoe Polish Co., 49 Dean St., with loss estimated at about $40,000.

Ohio

EMPIRE—The Miner Firebrick Co. has resumed operations at its local plant, following a curtailment for many months. The plant will give employment to about 75 operatives for an indifinite period.

BEDFORD—Officials of the Owen Tire & Rubber Co. are considering a plan for reorganization of the company. Manton M. Scott has been appointed receiver. The company has assets said to total $800,000 and liabilities of about $200,000. Operations at the plant will be continued pending the proposed reorganization.

Pennsylvania

NICHOLSON—Fire, Sept. 9, destroyed the celluloid department and other sections of the plant of the Lackawanna Cutlery Co., with loss estimated at about $75,000.

PHILADELPHIA — Fire, Sept. 14, destroyed a portion of the Point Breeze oil refinery of the Atlantic Refining Co., with loss estimated at about $100,000, including oil stills, etc.

South Carolina

LAURENS—The Laurens Brick Co. is planning for the construction of an addition to its plant on the Little River, to increase the daily output from about 30,000 to 40,000 bricks. H. C. Fleming is treasurer and manager.

KNOXVILLE—The Knoxville Fertilizer Co. has plans under way for the erection of a new plant at Vestal, near Knoxville, for the manufacture of commercial fertilizer products. The plant will consist of two main 1-story buildings, 160 x 350 ft. and 100 x 300 ft. respectively, and is estimated to cost about $300,000, including machinery. The initial works will have a daily output of close to 150 tons. James W. Dean is secretary and treasurer.

Texas

WACO—The Southwestern Portland Cement Co., El Paso, has acquired an extensive tract of property at Waco, comprising about 250 acres of land, and has preliminary plans under way for the erection of a new cement-manufacturing plant on a portion of the site. The initial works will cost about $1,500,000, including equipment. Carl Leonhardt is president.

THREE RIVERS—The Three Rivers Glass Co., 605 National Bank of Commerce Bldg., San Antonio, is perfecting plans for the erection of its proposed new glass-manufacturing plant at Three Rivers. The company has obtained a site with available high-grade glass sand. The new plant is said to be estimated to cost in excess of $100,000.

CISCO—The Cisco Clay & Coal Co. has commenced the erection of its proposed new brick-manufacturing plant, to specialize in the production of vitrified paving brick and kindred burned clay products. The plant will have an initial minimum capacity of about 50,000 bricks per day, and is estimated to cost about $200,000, including equipment. C. B. Bush is president.

DESDEMONA—The Magnolia Petroleum Co. has construction under way on a new casing-head gasoline plant, with initial capacity of about 3,000 gal.

West Virginia

MORGANTOWN—The Star Glass Co. is completing plans for the rebuilding of its local glass-manufacturing plant, recently destroyed by fire. The new works will consist of a main 1-story building, 145 x 500 ft., and two adjoining structures each 50 x 150 ft. A cooper shop and box factory will also be erected, as well as machine shop and other mechanical buildings for general operating and repair service. The new plant is estimated to cost about $225,000, with machinery. Louis Kauffield is general manager.

Wisconsin

PORT EDWARDS—The Nekeosa-Edwards Paper Co. is planning for the rebuilding of the portion of its plant, destroyed by fire, Sept. 2.

MILWAUKEE—The Red Star Yeast & Products Co., 79 Buffalo St., will soon commence the erection of a 1-story addition to its plant, 50 x 100 ft., on Twenty-seventh St., estimated to cost about $15,000.

Wyoming

CASPER—Effective Oct. 1, the Standard Oil Co. of Indiana, Indianapolis, will take over and operate the oil-refining plants of the Midwest Refining Co. at Casper, Graybull and Laramie, Wyo. General expansion in operations is planned. The Midwest company will continue as a producer of crude oil and will operate in the different Wyoming fields.

Ontario

TORONTO—The National Potashh Corp., Gravenhurst, Ont., has construction under way on a new plant for the manufacture of glass products. It is expected to have the works ready for service at an early date, with facilities to produce a general line of ware.

TORONTO—The Follansbee Bros. Co., Pittsburgh, Pa., is planning for operations at its new local steel plant, now in course of construction, early in October. The plant is being rushed to completion, with double working crews.

Nova Scotia

HALIFAX—Fire, Sept. 12, destroyed a portion of the refining plant of the Imperial Oil Co., at Dartmouth, near Halifax. It will be rebuilt.

Capital Increases, Etc.

THE HIGH FALLS PULP & PAPER Co., High Falls, N. Y., has filed notice of increase in capital from $150,000 to $600,000.

THE CORNING FOUNDRY Co., Corning, N. Y., manufacturer of iron and steel castings, etc., has filed notice of dissolution under state laws.

THE INDEPENDENT STARCH Co., 204 Franklin St., New York, N. Y., has filed notice of increase in capital from $30,000 to $100,000.

CLARK M. WHITTEMORE and EDMUND B. CLARY, Linden, N. J., have been appointed receivers for the Trans-Atlantic Chemical Co., operating a large local plant for the manufacture of chemicals, dyestuffs, etc. The application for receivership was made by William M. Stevenson, secretary of the company.

THE CONSUMERS' VEGETABLE GLUE Co., a Delaware corporation, has filed notice of organization to operate in Indiana for the manufacture of glues, pastes, etc. F. B. Shields, Indianapolis, represents the company.

THE LAKE CHAMPLAIN PULP & PAPER Co., Plattsburg, N. Y., has filed notice of dissolution under state laws.

THE MITCHELL LIME Co., Mitchell, Ind., has filed notice of change of name to the Lehigh Lime Co.

THE THOMPSON-CASE OIL & RUBBER Co., Chattanooga, Tenn., has filed notice of increase in capital from $15,000 to $50,000. The company formerly was known as the Thompson-Case Rubber Co.

THE UNITED STATES CHINA Co., Chesterton, Ind., manufacturer of chinaware, has filed notice of increase in capital from $200,000 to $875,000, at the same time changing its name to the American China Products Co.

THE SOUTHERN GYPSUM Co., North Holston, Va., manufacturer of gypsum products, has filed notice of increase in capital from $500,000 to $750,000.

THE CORTLAND TIRE & RUBBER Co., Cortland St., Belleville, N. J., has filed notice of dissolution under state laws.

New Companies

THE AMERICAN OXYGEN CORP., Boston, Mass., has been incorporated with a capital of $100,000, to manufacture commercial oxygen and affiliated products. Charles E. Donlan is president; Clinton B. Sherwood, Swampscott, Mass., is treasurer.

THE DRY PAINT CORP., Detroit, Mich., has been incorporated with a capital of $10,000, to manufacture paints, varnishes, etc. The incorporators are George A. Smith, Lowry C. M. Conley and Andrew B. Couchman, 1529 Glendale St.

THE OIL REDUCTION Co., Hudson, N. Y., has been incorporated with a capital of $300,000 under Delaware laws, to manufacture refined oil products. The incorporators are Rigland S. Eagles, Hudson; Eugene F. Dumennil and Walter S. Griffin. The company is represented by the Delaware Registration Trust Co., 900 Market St., Wilmington, Del.

THE FERMANOS CHEMICAL Co., Brooklyn, N. Y., has been incorporated with a capital of $10,000, to manufacture chemicals and chemical byproducts. The incorporators are B. Barbera and F. Maggio. The company is represented by Giaccone & Richard, 154 Wilson Ave., Brooklyn.

THE CHATTANOOGA MIRROR PLATE Co., Chattanooga, Tenn., has been incorporated with a capital of $20,000, to manufacture mirrors and other glass products. The incorporators are F. R. Hymes and Spaulding Hoffman, Chattanooga.

THE ILLINOIS-ARKANSAS OIL Co., Havana, Ill., has been incorporated with a capital of $45,000, to manufacture petroleum products. The incorporators are E. J. List, H. A. Starkweather and Carl H. Hillemeyer, 121 South Orange St., Havana.

THE PEP GLAND Co., Jersey City, N. J., has been organized to manufacture chemicals and chemical byproducts. The company is headed by J. R. and B. F. Cortese, and P. G. Flint, 5 Montgomery St.

THE JOHN E. DANIELS LEATHER Co., Boston, Mass., has been incorporated with a capital of $20,000, to manufacture leather products. John E. Daniels, 69 Kenwood St., Brookline, Mass., is president and treasurer.

THE ZOCH-BARNES PETROLEUM CORP., Wilmington, Del., has been incorporated with a capital of $5,000,000, to manufacture refined oil products. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington.

THE HOBOKEN RUBBER Co., 54 Fourteenth St., Hoboken, N. J., has filed notice of organization to manufacture rubber products. The company is headed by Frank J. Doran, 1221 Washington St.

THE ARNOLD CHEMICAL Co., Boston, Mass., has filed notice of organization to manufacture chemical products. The company is headed by A. S. Brodie, 120 Milk St.

THE ROCHELL PRODUCTS Co., Philadelphia, Pa., has been incorporated under Delaware laws with a capital of $100,000, to manufacture chemicals and chemical byproducts. The incorporators are Harry Rochell, William J. Dougherty and Martin J. Lyons. The company is represented by Philip L. Garrett, Equitable Building, Wilmington, Del.

THE INTERSTATE PETROLEUM PRODUCTS Co., Fort Wayne, Ind., has been incorporated with a capital of $100,000, to manufacture refined oil products. The incorporators are J. F. Bippus Frank Martin and Milton Matter, Fort Wayne.

THE ROXBURY STEEL CASTING Co., Boston, Mass., has been incorporated with a capital of $50,000, to manufacture steel and other metal castings. Isaac E. Sexton is president; Perley C. Rogers, Quincy, Mass., is treasurer.

THE PHOENIX BELTING & OIL Co., 198 Pacific St., Newark, N. J., has been incorporated with a capital of $100,000, to manufacture oils, greases, leather belting, etc. The incorporators are Benjamin, Matthew M., and Leon Gallop, address noted.

THE SANITARY BOTTLE MFG. Co., West Pittston, Pa., has been incorporated with a capital of $200,000 under Delaware laws, to manufacture bottles and other glass containers. The incorporators are L. O. Culver, West Pittston; George W. Culver, Forty-Fort, Pa.; and D. O. Coughlin, Luzerne, Pa. The company is represented by the Capital Trust Co. Dover, Del.

THE SETH LEE FIREBRICK Co., Boston, Mass., has been incorporated with a capital of $300,000, to manufacture firebrick and other refractory products. Thomas W. Pelham is president; Martin J. Lee, vice-president; and Seth Lee, 100 Carver St., Newton Highlands, Mass., treasurer.

THE ABBOTT-CADE ENAMELING Co., Dallas, Tex., has been incorporated with a capital of $10,000, to manufacture enameled products. The incorporators are N. F. Wertheimer, H. L. Bromberg and C. S. Reynolds, Dallas.

THE RIVERSIDE BRICK & TILE Co., Knoxville, Tenn., has been incorporated with a capital of $40,000, to manufacture brick, tile and other burned clay products. The incorporators are R. P. Black, J. W. Dooly and B. C. Ogle, Knoxville.

THE WAUKEGAN FOUNDRY Co., Waukegan, Ill., has been incorporated with a capital of $60,000, to manufacture iron, steel and other metal castings. The incorporators are Andrew K. Barr, Elmer T. Kidmore and Elmer Olavey. The company is represented by Benjamin Farmalee, Waukegan.

THE EL DORADO REFINING Co., New York, N. Y., has been incorporated with a capital of $500,000 under Delaware laws, to manufacture refined oil products, with plant in the vicinity of Texarkana, Tex. The incorporators are G. W. and L. A. Merrill, Texarkana; and L. F. Severson, Tulsa, Okla. The company is represented by the United States Corporation Co., 65 Cedar St., New York.

THE KRANISH CHEMICAL Co., Brooklyn, N. Y., has been incorporated with a capital of $20,000, to manufacture chemicals and chemical byproducts. The incorporators are A. and H. Kranish, and J. G. Turnbull, 27 Cedar St., New York.

THE TRAVERTINE PRODUCTS CORP., Livingston, Mont., has been incorporated with a capital of $500,000, to manufacture cement, lime and kindred products. The incorporators are C. T. Sackett and L. R. Nye, Livingston.

THE INDUSTRIAL SUPPLY Co., New Haven, Conn., has been incorporated with a capital of $10,000, to manufacture chemicals, polishing materials, etc. The incorporators are James F. and M. Toole, 144 Townsend St., New Haven.

THE KAOLIN PRODUCTS CORP., Los Angeles, Cal., has been incorporated with a capital of $500,000, to produce kaolin, clays and kindred products. The incorporators are G. A. Eichelberger, M. L. Gilmore and H. P. Goodwin, 232 Title Insurance Bldg., Los Angeles.

THE VANO PRODUCTS Co., New York, N. Y., has been incorporated with a capital of $10,000, to manufacture chemical compounds and affiliated products. The incorporators are F. A. Nelson, I. Price and J. Weiner. The company is represented by Price Bros., 261 Broadway.

THE MOUNTAIN CITY CHEMICAL Co., Fairmont, W. Va., has been incorporated with a capital of $100,000, to manufacture chemicals and chemical byproducts. The incorporators are R. P. and C. E. Hutchinson, and J. V. Abbott, Fairmont.

THE OLYMPIC OIL CORP., Tralee, W. Va., has been incorporated with a capital of $100,000, to manufacture petroleum products. The incorporators are J. C. Sullivan and J. F. Korner, Tralee.

THE INDIANAPOLIS MOLDED RUBBER PRODUCTS Co., Indianapolis, Ind., has been incorporated with a capital of $100,000, to manufacture rubber products and composition specialties. The incorporators are F. L. Tompkins and T. S. Stewart, Indianapolis.

THE OREGON CHARCOAL IRON Co., Portland, Ore., has been incorporated with a capital of $500,000, to operate a smelting plant. The company is headed by J. H. Kelly, 1524 Yeon Bldg., Portland.

THE HAMMOND GREASE & OIL Co., Hammond, Ind., has been incorporated with a capital of $15,000, to manufacture greases, lubricating oils, etc. The incorporators are M. M. Dermody, O. B. Loyd and W. H. Breckenridge, Hammond. The last two noted incorporators have also organized the Lloyd-Breckenridge Grease Co., Hammond, to manufacture greases, soaps, oils, etc.

THE MAXWELL PAINT Co., Philadelphia, Pa., is being organized by H. C. Middleton, Roy M. Boyd and William A. Stuetz, to manufacture paints, varnish, sizing and kindred products. J. Claude Bedford, Liberty Bldg., represents the company. Application for a state charter will be made on Oct. 3.

THE ALABAMA LIME Co., Chattanooga, Tenn., has been incorporated with a capital of $10,000, to manufacture lime products. The incorporators are A. C. Noone, Horace Hamby and C. N. Miles, Chattanooga.

Industrial Notes

SIECK & DRUCKER, INC., mechanical and chemical engineer, Chicago, Ill., announces it has associated with itself Herbert Sieck, formerly in charge of operations of the Chicago properties of the American Cocoanut Butter Co.

THOS. FIRTH & SONS, LTD., Sheffield, England, has terminated its agency arrangement for the sale of sheet steel heretofore existing between it and Wheelock Lovejoy & Co., of New York and Cambridge, and has appointed Horace G. Hides as general sales manager for the United States. This company and the Firth-Sterling Steel Co., an associate company of New York, have opened a joint office in Hartford, Conn., where Mr. Hides will have his headquarters for the former company and Henry I. Moore will represent the latter company. The stock of the Firth Sheffield sheets will be carried in the warehouse of the Firth-Sterling Steel Co., New York City.

GEORGE C. D. LENTH has been appointed secretary of the Clay Products Association, with offices in Chicago, to succeed the late George H. Tefft. Mr. Lenth is a graduate of the Massachusetts Institute of Technology and has for some time been chief engineer of sewers of the City of Chicago. He will follow out one of the chief lines of endeavor of this society at the present time—namely, the promotion of vitrified and salt glazed sanitary sewer pipe to resist chemical action of sewage.

STUART CROASDALE & Co. announce the removal of Pittsburgh offices from the Magee Bldg. to 946 Union Arcade Bldg.

THE LINK-BELT Co., Chicago, announces a practically uniform reduction of 10 per cent on malleable iron and steel (SS Class) chains, sprockets, buckets and other products, effective at once.

THE GENERAL ALLOYS Co., New York and Chicago, announces a new heat-resisting alloy, under the trade name of X-ite. It is the fourth standard material to be sold by this company under the Q alloy trade name.

THE TEXAS GULF SULPHUR Co. announces the removal of its offices to larger quarters in the Liggett Bldg., at 41 East 42nd St., New York.

E. I. DU PONT DE NEMOURS & Co., Wilmington, Del., announce that Cesare Protto has been appointed assistant director of the sales division of the dyestuffs department in place of E. V. Patterson, who has re-

signed. Robert S. Lunt has been appointed manager of the Boston office of the dyestuffs sales division, with Charles H. Scott as assistant manager.

DWIGHT P. ROBINSON CO., INC., New York, has published a chart showing the range of index numbers of wholesale prices by groups of commodities by months, 1913-1921.

ROGERS, BROWN & CO., Cincinnati, Ohio, have been appointed sole agents in the United States for the sale of Virgin aluminum, of various grades, produced by the Norsk Aluminum Co. of Christiania, Norway. Stocks of aluminum will be carried at the New York City and Cleveland, Ohio, offices of the company.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., has moved its Cincinnati office from the Gwynne Bldg. to the Dixie Terminal Bldg. A. R. Maujer, formerly of the sales-engineering force of the Pittsburgh office, is now in charge of the Cincinnati office.

THE CHICAGO FLEXIBLE SHAFT CO. has placed Ralph C. Schwarz in charge of the northwestern New York territory for the distribution and sale of Stewart industrial furnaces and appliances. Mr. Schwarz's address will be 921 Granite Bldg., Rochester, N. Y.

FORD, BACON & DAVIS, New York, have opened an office in Philadelphia at 1421 Chestnut St. This engineering firm has the following departments, which are adapted to meet present economic conditions: Engineering, report, valuation, accounting, construction, management and financing.

THE SOCIETE ANONYME DES USINES GIULINI, Basel, Switzerland, manufacturer of Virgin aluminum ingots, notched bars, bars, plates and sheets, has appointed C. W. Leavitt & Co. sole selling agents for the United States and Canada.

THE M. H. DETRICK CO., Chicago, maker of Detrick arches and Detrick-Hagan steam jet ash conveyors, announces the appointment of H. W. Thompson, 503 Mining Exchange Bldg., Denver, Col., as sales representative in that territory.

THE W. A. JONES FOUNDRY & MACHINE CO., Chicago, has elected T. A. Jones president, to take the place of William A. Jones, deceased. Mr. Jones has been for many years associated with the company as secretary and treasurer and is largely responsible for its firm position. Other officers elected are: W. G. Jones, vice-president and treasurer; J. A. Sizer, secretary; G. W. Page, assistant secretary. The general policy of the company is in no way altered by these changes and W. G. Jones continues as general manager in addition to his new position as vice-president and treasurer. This company also announces the appointment of Robert B. Moir as manager of its New York branch.

THE RADIUM LUMINOUS MATERIAL CORP. at a recent meeting of the board of directors decided to change its name to the United States Radium Corp. The control and management of the corporation remain unchanged.

BANKS & CRAIG, engineers and chemists, have moved to new quarters at 51 East 42nd St., New York City.

THE TECHNICAL CREDIT ASSOCIATION, 2 Rector St., New York City, announces that it is organized to make investigations including: Geological, chemical, mining, metallurgical, electrical, with expert sampling and accounting, efficiency engineering and appraisal of raw material resources and supplies, equipment, processes and management of properties and operations, for the purpose of sustaining or establishing credit.

HUNGERFORD & TERRY, Philadelphia, Pa., have appointed the Hurricane Engineering Co., 53 State St., Boston, Mass., selling agents for its apparatus in the New England territory. The managing director of the Hurricane Engineering Co. is E. L. Smith, for years the New England representative of the Philadelphia Drying Machine Co. The entire line of water filters, water softeners, iron removal plants, hypochlorite feeds and other feeding devices manufactured by Hungerford & Terry, Inc., will be handled by the Hurricane Engineering Co.

F. J. RYAN & Co., Philadelphia, Pa., announce the establishment of three additional agencies. They are as follows: Detroit, under the direction of David P. Harr, 423 Depot St., Latrobe, Pa., who will also cover the Cleveland and Toledo districts; Chicago, under the direction of the Singer Kennedy Construction Co., 39 W. Adams St., Chicago, Ill., who will cover the Middle West; L. H. Chamberlain, 72 New Montgomery Ave., San Francisco, Cal., will cover the Pacific Coast. F. J. Ryan & Co. have recently moved their general offices and sales from the Franklin Trust Bldg. to larger quarters in the Wesley Bldg., 17th St. and the Parkway, Philadelphia, Pa. The removal is also announced of the engineering departments to Lancaster, where they will be established in the headquarters of the Lancaster Iron Works, with which F. J. Ryan & Co. became associated in the early part of the present year.

J. SCHANZENBACH & Co. has been organized by former department heads of the old house of Laidlaw-Kelly & Co., and is organized to engage in handling chemicals, oils, waxes, dyestuffs, etc. The company's office is 74 Cortlandt St., New York City.

L. R. CHRISTIE CO., engineer, Pittsburgh, Pa., specializing in the design of drying machinery, has granted the Duff Patents Co. of Pittsburgh sole license and rights to manufacture driers of the Christie patents and design.

New Publications

BOOKS

THE MINERAL INDUSTRY OF THE BRITISH EMPIRE AND FOREIGN COUNTRIES. Statistical Summary (Production, Imports and Exports), 1913-1920. 104 pages. London: Printed by H. M. Stationary Office, 1921. Price 3s. 0d. net.

This title sufficiently describes the scope of the book which is planned to be the first of series of annual volumes. It consists of tabular matter exclusively, with no textual comment, but covers the war years fully, 1919 completely, and 1920 in part. Particularly valuable will be the figures for the mineral production of the enemy countries. Not only are minerals, such as chromite, asbestors and gypsum, included, but metals, such as copper, ferromanganese, silver, etc.

WATER POWERS OF GEORGIA, THIRD REPORT. By *B. M. Hall* and *M. R. Hall*. Pp. 316, illustrated. Atlanta, Ga.: Geological Survey of Georgia, 1921.

USEFUL INFORMATION FOR COTTON MANUFACTURERS, VOL. IV, AIR CONDITIONING, second edition. Compiled and issued by *Stuart W. Cramer*, Charlotte, N. C.

A study of air-conditioning problems as related to textile mills, with a description of the Cramer system of air conditioning.

CONCENTRATION BY FLOTATION. Compiled and edited by *T. A. Rickard*. Pp. 692, illustrated. New York: John Wiley & Sons, Inc., 1921. Price, $7.

Forty articles dealing with all phases of the flotation process which appeared in the *Mining and Scientific Press* during the years 1915 to 1920 have been brought together in book form by the editor. This compilation will thus serve as a convenient compendium of the principal literature on the technology of flotation.

COLORIMETRIC ANALYSIS. By *F. D. Snell*. Pp. 150; illustrated. New York: D. Van Nostrand Co., 1921. Price, $2.

This book is an attempt to combine in one volume for ready reference all the colorimetric tests which experience has shown to be at all practical. These have been grouped under the heads: Iron; copper; carbon in steel; lead, bismuth and arsenic; aluminum and chromium; nickel, cobalt, manganese and zinc; potassium and magnesium; gold; titanium, vanadium and tungsten; fluorine, chlorine and perchlorates; nitric and nitrous acids, ammonia; phosphorus, silica and boron; oxygen and hydrogen peroxide; sulphur, hydrogen sulphide and selenious acid; salicylic acid and cyanides; water, oils and dyes. Chapters on conditions of use of colorimetric methods, colorimetric apparatus and its use, and nephelometry are also included.

ELEMENTARY QUANTITATIVE ANALYSIS OF THE METALS AND ACID RADICALS. By *Frederick C. Reeve, E.E.*, acting head of the department of physics and chemistry at the East Side High School, Newark, N. J. Pp. 143. New York: D. Van Nostrand, 1921. Price, $1.50.

An elementary laboratory manual.

THE ENGINEERING INDEX, 1920. Pp. 586. New York: The American Society of Mechanical Engineers, 1921. Price, $6.

Nearly 14,000 items referring to articles in 700 engineering and allied technical publications will be found in this index. The alphabetical arrangement which proved to be so convenient and satisfactory in the 1919 volume has been retained. Each item contains the exact title of the article indexed; the author's name, if given; the name of the publication; the volume, number and date; the page numbers and number of figures. It also includes a brief note summarizing the article indexed.

Manufacturers' Catalogs

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., calls attention to bulletin 1118, descriptive of its new line of continuous rated polyphase induction motors, covering the type "AR" squirrel cage line, and type "R" potential starter; Leaflet 1459 entitled "Fullers Earth," which relates to rotary kilns for reclaiming this product, and Bulletin 1106 A, on "Type 'E' Direct-Current Motors and Generators."

W. S. ROCKWELL CO., New York, has issued a very interesting and instructive pamphlet on Furnace Design. It contains 13 pages of outline drawings showing the essential parts of over 250 different styles of heating and heat-treating and melting furnaces and muffles, both manual and automatic, intermittent and continous, regenerative and otherwise. The pamphlet closes with a drawing showing about three dozen arrangements of furnace chambers and working openings to which nearly all of the types illustrated could be adopted. This company also announces that a general misunderstanding of principles governing the selection of fuel and equipment for industrial heating operations has led it to issue a pamphlet which contains a series of papers relating to the selection and use of fuels and equipment for industrial heating operations.

THE PENNSYLVANIA TANK LINE, Sharon, Pa., calls attention to its attractive catalog entitled "The Tank Car." All of the latest special rulings, traffic regulations and repair charges as fixed by the American Railway Association have been included in this catalog. It also shows in detail the numerous accounting forms, technical engineering charts and half-tone reproductions of this company's construction.

THE ANTI-HYDRO WATERPROOFING CO., Newark, N. J., has issued a leaflet on "Anti-Hydro," which hardens and waterproofs concrete.

Coming Meetings and Events

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its seventy-fourth meeting at Toronto, Canada, Dec. 27 to 31, 1921.

AMERICAN CERAMIC SOCIETY will hold its twenty-first annual meeting at St. Louis, Feb. 27 to March 2, 1922.

AMERICAN GAS ASSOCIATION will hold its third annual convention in the Congress and Auditorium Hotels, Chicago, the week of Nov. 7. More than 100 manufacturers will exhibit their latest gas-burning appliances.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its fall meeting at Lake Placid, N. Y., Sept. 29 and 30, and Oct. 1.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its annual winter meeting at Baltimore, Md., Dec. 6 to 9. Headquarters will be at the Southern Hotel and the sessions will be held in the Engineers' Club.

AMERICAN MINING CONGRESS AND NATIONAL EXPOSITION OF MINES AND MINING EQUIPMENT will hold its twenty-fourth annual convention in the Coliseum, Chicago, Oct. 17 to 22.

INDUSTRIAL COST ASSOCIATION will hold its second national conference at Pittsburgh, Pa., Nov. 2-4, with headquarters at the William Penn Hotel.

INDUSTRIAL RELATIONS ASSOCIATION OF AMERICA will hold its annual convention at the Waldorf-Astoria, New York, Nov. 1-5.

NATIONAL SAFETY COUNCIL is holding its tenth annual conference at the State House, Boston, Mass., Sept. 26 to 30.

NEW JERSEY CHEMICAL SOCIETY has discontinued meetings for the summer and will resume them in October.

SOCIETY OF INDUSTRIAL ENGINEERS will hold its fall meeting at Springfield, Mass., Oct. 5 to 7.

The following meetings are scheduled to be held in Rumford Hall, the Chemists' Club, New York: Oct. 7—American Chemical Society, regular meeting; Oct. 14—Société de Chimie Industrielle, regular meeting; Oct. 21—Society of Chemical Industry, Grasselli Medal; Nov. 11—American Chemical Society (in charge), Society of Chemical Industry, American Electrochemical Society, Société de Chimie Industrielle, joint meeting; Nov. 18—American Electrochemical Society, regular meeting; Dec. 2—Society of Chemical Industry, regular meeting; Dec. 9—American Chemical Society, regular meeting.